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NILAN RESERVOIR

EAST DAM and NORTH DAM

MANUAL FOR OPERATION AND MAINTENANCE

State Water Projects Bureau
Water Resources Division
Department of Natural Resources and Conservation
48 North Last Chance Gulch
P.O. Box 201601
Helena, MT 59620-1601

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OVERVIEW

Both dams on Nilan Reservoir are located in Lewis and Clark County, approximately 7 miles west of Augusta, Montana (see Figures 1 and 2). This off-stream reservoir is fed from supply canals from Smith and Ford Creeks. There is a distribution canal located at the outlet of each dam. Figure 3 provides a general layout of the dams, spillway and outlet works. Figures 4 and 5 show the location of the monitoring wells at the East and North dams.

The dams are owned by the Montana Department of Natural Resources and Conservation (DNRC) and are managed by the State Water Projects Bureau (SWPB) of the DNRC. The Nilan Water Users Association (herein called the "association") operates and maintains the dams.

Both earthfill dams were completed in 1951. Nilan East Dam is 51 feet high and 1,010 feet long. The North Dam is 54 feet high and 530 feet long. Appurtenant to the North Dam is a 1,300-foot-long dike, which extends generally east from the east abutment along a low area in the topography. The dike has the same crest elevation as the North Dam and has a maximum height of 8 feet, with the same side slopes and crest width as the dam. The outlet works of each dam consists of a double chambered wet tower and a 48-inch square slide gate with a 48-inch square emergency slide gate. Controls for both gates are at the top of the tower. The maximum capacity of the East Dam outlet is 385 cubic feet per second (cfs) and the maximum capacity of the North Dam outlet is 395 cfs. County road S-435 crosses the crest of the East Dam.

The spillway is located in a natural swale approximately 370 feet northwest of the north abutment of the East Dam and releases water into the Elk Creek drainage. The water flows across county road S-435 when the spillway is operating. The spillway has a concrete control section which functions as a low drop structure. The maximum capacity of the spillway is 8,620 cfs.

Water from the reservoir is primarily used for irrigation water supply. The reservoir is also used for water-based recreation.

In the spring of 1999, several small and one large (6 feet by 8 feet) sinkholes were discovered along the upstream toe of the East Dam embankment. Repair of the sinkholes started on April 27, 1999, and was completed on May 17, 1999. The repairs consisted of removing the existing native material, placing a compacted base of granular material, installing a geotextile fabric on the excavated face of the dam, placing a bentonite liner (GCL) around the perimeter and bottom of the excavation, and then replacing and compacting the native clay material. A compacted granular layer of sand and gravel was placed on top of the native clay material, and then a geotextile fabric was placed over the area. Riprap was placed on the geotextile blanket to protect the repairs from erosion.

In the fall of 1999 after the reservoir had been substantially lowered due to irrigation withdrawls, another sinkhole was discovered immediately north of the previous repair. Work to repair this sinkhole started on November 2, 1999 and was completed on December 18, 1999. This repair was tied into the previous work. The repair extended northerly from the right abutment for approximately 320 feet and extended about 90 feet from the upstream toe of the dam toward the lake. This second larger repair effort was similar in design to the previous effort. Slight modifications were made to increase slope stability above the GCL.

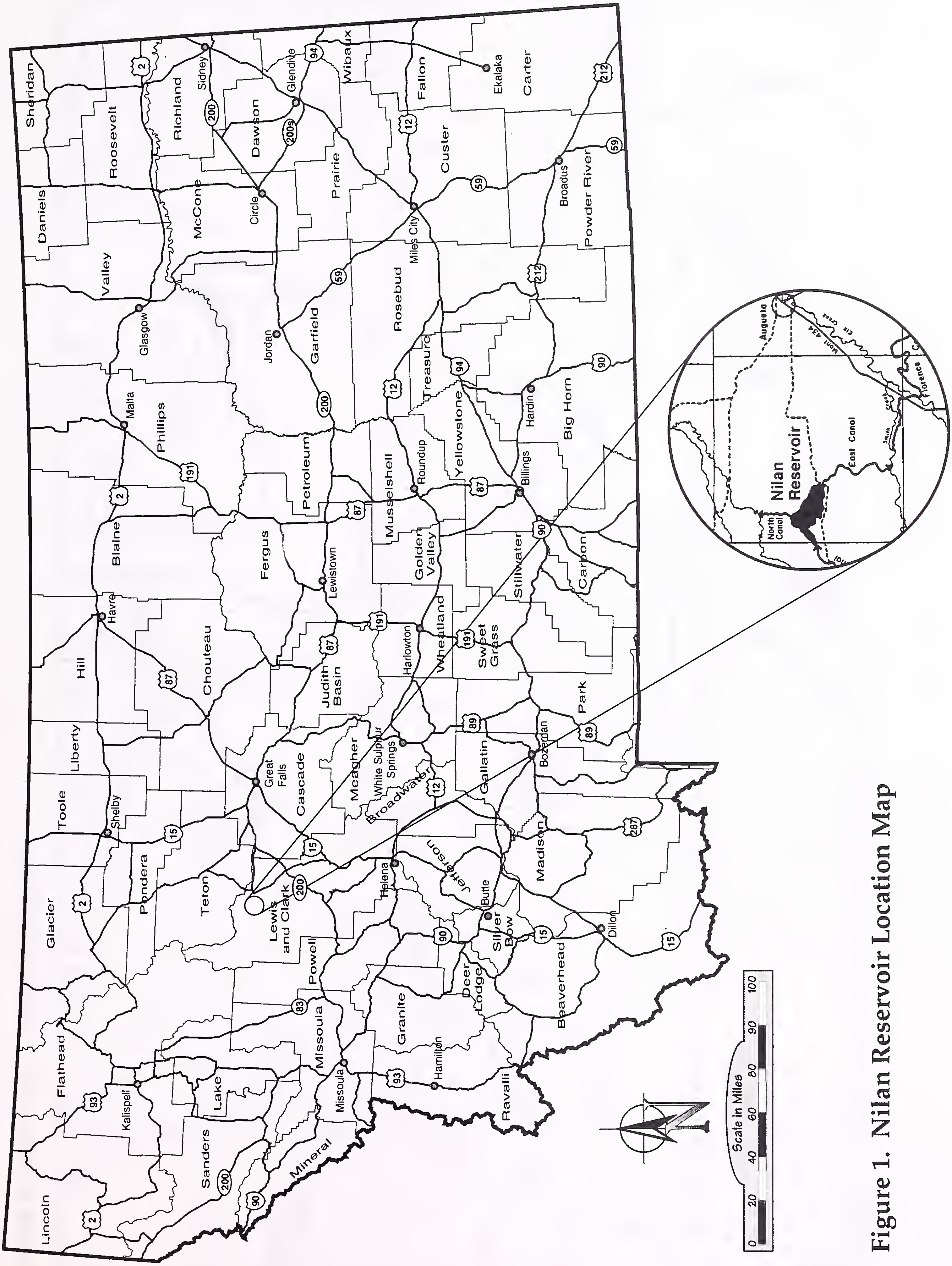


Figure 1. Nilan Reservoir Location Map

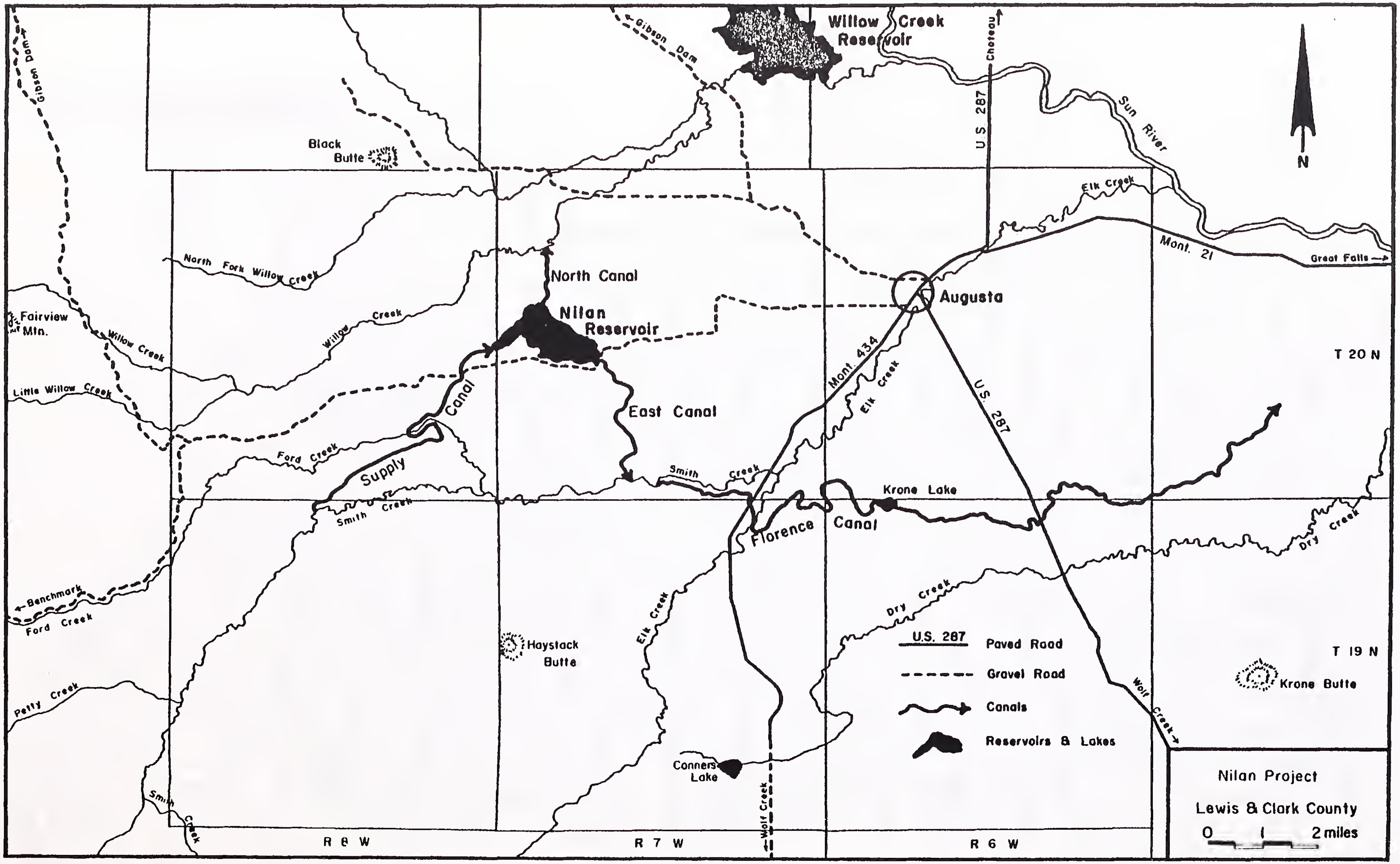


Figure 2. Nilan Reservoir Project Map

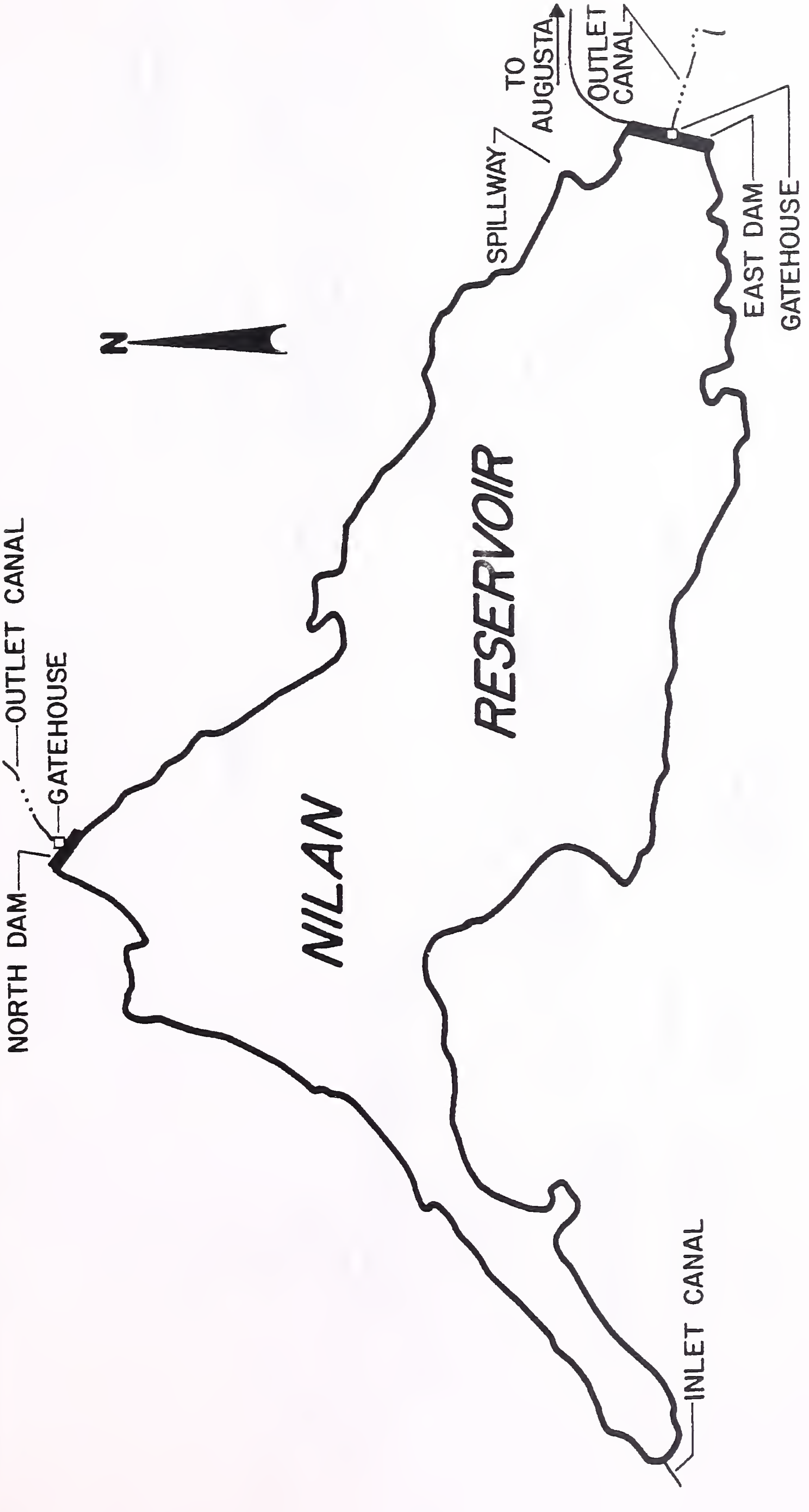


Figure 3. Nilan Reservoir General Layout

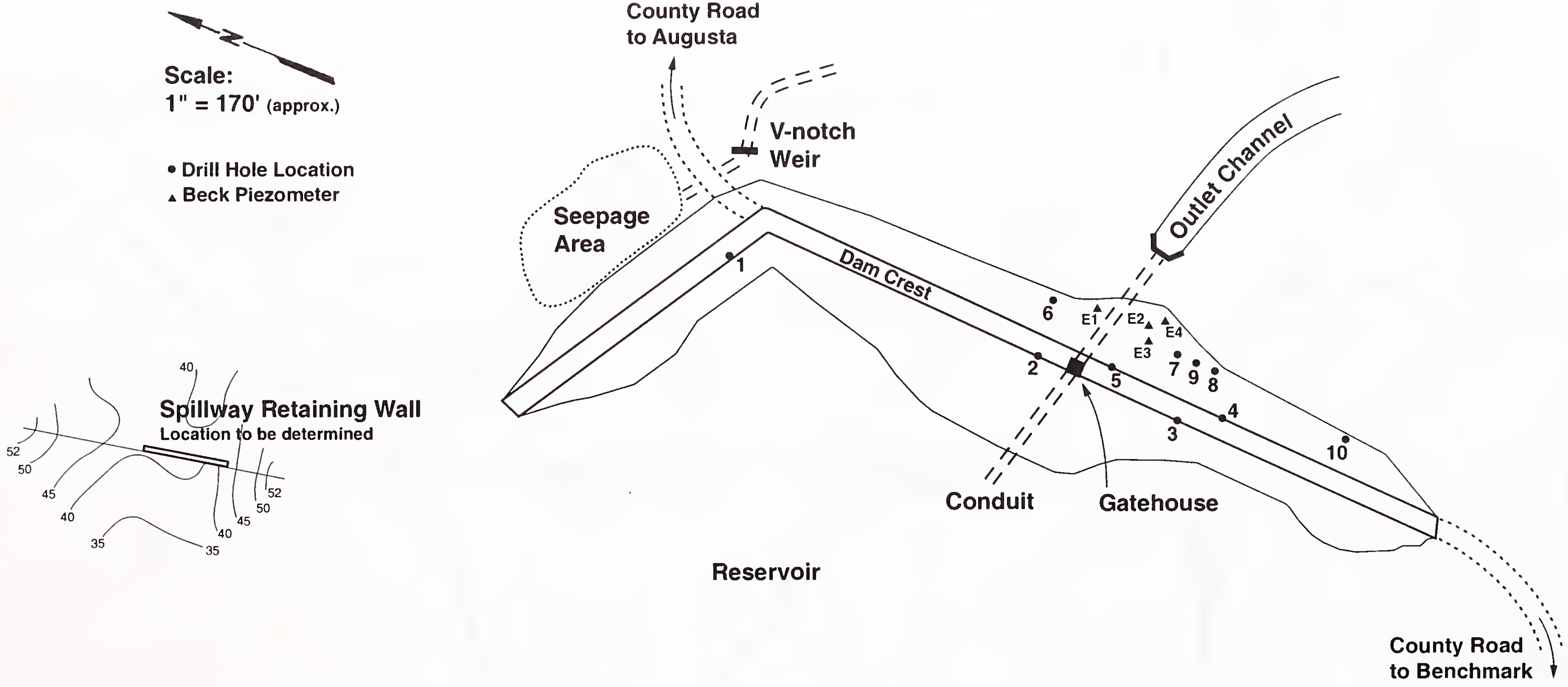


Figure 4. Nilan East Dam Monitoring Well Location

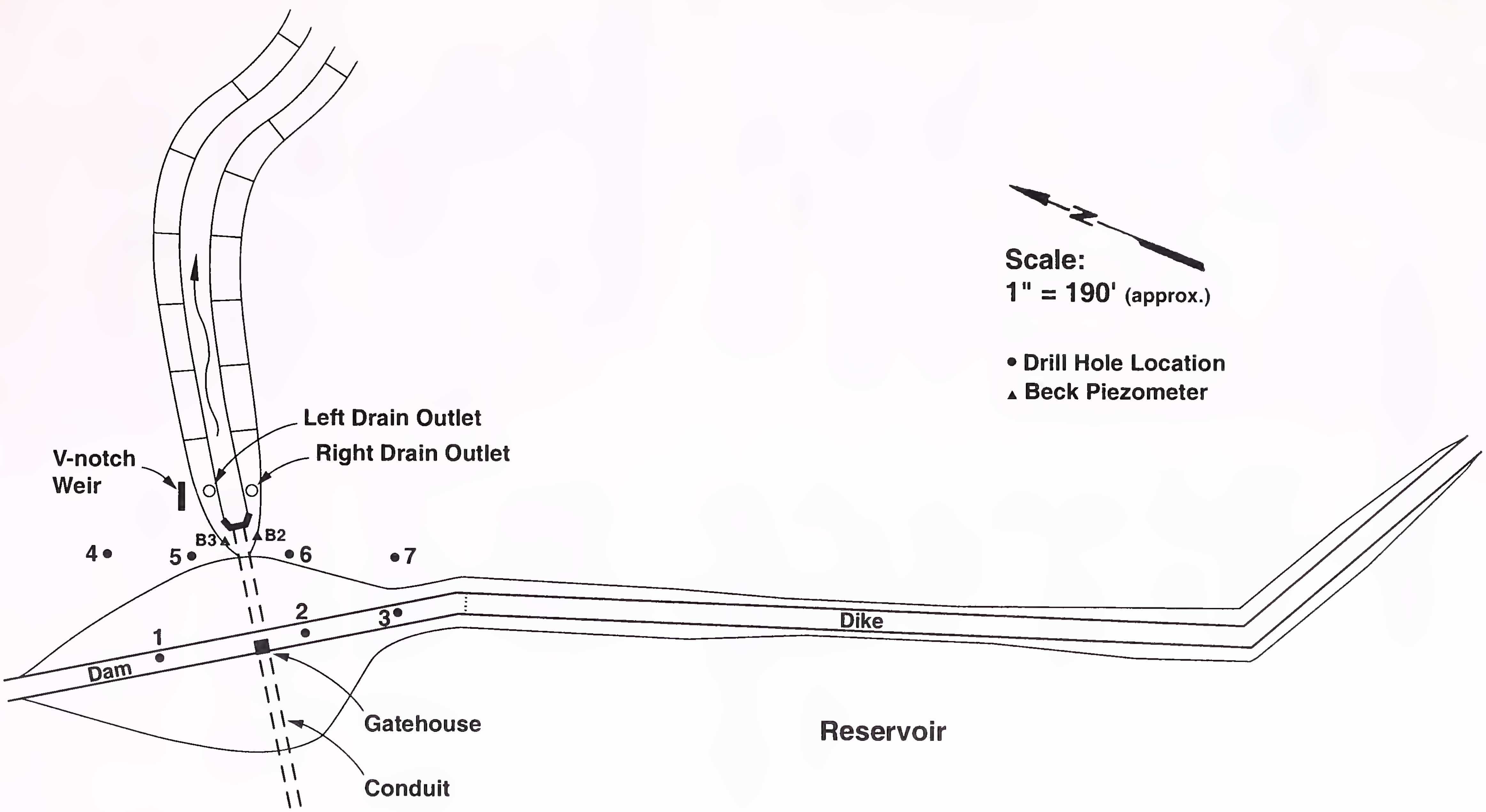


Figure 5. Nilan North Dam Monitoring Well Location

STATISTICAL INFORMATION

1. General

a. Owner	Montana Department of Natural Resources and Conservation (DNRC)
b. Operator	Nilan Water Users Association
c. Location	Sections 17, 18 (North Dam), 19 and 20 (East Dam), Township 20 North, Range 7 West
d. Latitude, East Dam	47° 28' 24"
Longitude, East Dam	112° 32' 18"
Latitude, North Dam	47° 29" 12"
Longitude, North Dam	112° 32' 18"
e. County/State	Lewis and Clark/Montana
f. Watershed Location	Between Willow Creek and Elk Creek, Sun River Basin.

2. Principle Elevations

a. Minimum Dam Crest	4,452.0 feet
b. Normal Full Pool	4,442.5 feet
c. Spillway Crest	4,442.5 feet
d. Outlet Conduit Invert (design)	
East Dam	4,400.75 feet
North Dam	4,397.25 feet

3. Reservoir

a. Length of Maximum Pool	0.78 miles
b. Maximum Reservoir Level of Record	4,442.9 feet (7/15/78)
c. Surface Area (at normal full pool)	525 acres

4. Storage

a. Maximum Storage (pool at dam crest)	15,600 acre-feet
b. Active Storage (pool at spillway crest)	10,092 acre-feet
c. Maximum Surcharge (from spillway to dam crest)	5,508 are-feet

5. Hydrology

a. Inflow Design Flood	½ Probable Maximum Flood (½ PMF) (12,400 cfs peak flow)
b. 100-Year Flood	421 cfs
c. 500-Year Flood	839 cfs

6. Embankment (East Dam)

a. Type	Earthfill
b. Hydraulic Height	51 feet
c. Crest Length	1,010 feet
d. Crest Width	20 feet
e. Upstream Slope	1v on 2h and 1v on 1.8h
f. Downstream Slope	1v on 2h

7. Embankment (North Dam)

a. Type	Earthfill
b. Hydraulic Height	51 feet
c. Crest Length	530 feet
d. Crest Width	20 feet
e. Downstream Slope	1v on 2.0h
f. Upstream Slope	1v on 2.0h

8. Embankment (North Dike)

a. Type	Earthfill
b. Hydraulic Height	8 feet
c. Crest Length	1,300 feet
d. Crest Width	20 feet
e. Downstream Slope	1v on 2.0h
f. Upstream Slope	1v on 2.0h

9. Outlet Works (East Dam)

a. Size	4-foot diameter, cast-in-place concrete conduit
b. Length	250 feet
c. Control	Double-chambered wet well located on the upstream edge of the dam crest with a 48-inch diameter operating sluice gate and a 48-inch by 48-inch square emergency slide gate.
d. Capacity at Dam Crest (pool at dam crest)	385 cfs
e. Trashrack	Yes

10. Outlet Works (North Dam)

a. Size	4-foot diameter, cast in place concrete conduit
b. Length	626 feet
c. Control	Double-chambered wet well located on the upstream edge of the dam crest with a 48-inch diameter operating sluice gate and a 48-inch by 48-inch square emergency sluice gate
d. Capacity at Dam Crest (pool at dam crest)	395 cfs
e. Trashrack	Yes

11. Spillway

a. Type	Unlined channel with concrete control weir
b. Crest Width	72 feet
c. Weir Size	1.8 feet high x 0.75 feet wide
d. Capacity (pool at dam crest)	8,620 cfs

OPERATING PROCEDURES

The association operates the Nilan Dams and reservoir to provide an adequate supply of irrigation water to meet contracts with the water users without exceeding safe storage and flow levels.

METHOD AND SCHEDULE OF OPERATION

The association's goal is to have the reservoir full before contract holder's start calling for water. For the past several years, the inlet canal has rarely been turned off. The inlet canal is operated during winter as long as icing is not a problem. Even when icing does occur, some water continues to run through the canal under the ice.

The date irrigation releases begin varies from year to year, with May 1 the earliest that releases can begin. During typical years, releases begin around June 1 and end by September 30 as specified in the water purchase contracts. All dates tend to vary depending on each year's climatological and hydrological conditions.

Maximum Winter Storage: The maximum reservoir elevation for winter storage is 4,437.0 feet with 7,407 acre-feet of storage. This winter maximum helps prevent damage to the riprap and embankment from wind-driven waves and ice.

Minimum Winter Storage: The minimum reservoir elevation for winter storage is 4,409.0 feet with 525 acre-feet of storage. This winter minimum helps prevent ice damage to the inlet structure for the outlet works, minimizes water quality problems, and helps to maintain the fishery.

SAFE DRAWDOWN

Because neither of the Nilan Dams has been thoroughly investigated relative their structural stability, the DNRC recommends that drawdown rates not exceed one foot per day.

LIMITS OF APPURTENANCES

Appurtenances at Nilan Reservoir include the supply and delivery canals, outlet works, and spillway. The supply canals' capacity is listed as 300 cfs. The maximum combined capacity of the delivery canals is 149 cfs. At the maximum dam crest elevation, the combined outlet works' capacity is 780 cfs. In addition, the spillway will discharge 8,620 cfs with the pool at the dam crest elevation. If the outlet works are operated far in excess of the delivery canals' capacity, the canals and canal structures can be damaged. Outlet rating tables are shown in Appendix A.

The maximum gate opening for the outlet gates on the project is 4 feet. Openings in excess of this amount may damage the gates, gate frames, gate stems or the gate operating pedestals. The 4 feet of operation is measured on the exposed portion of the gate stem between the top of the pedestal stem and the bottom of the stop nut.

DAM OPERATOR

The responsibility for the daily operation of the canals, dams, and reservoir rests with the association and the dam operator. The dam operator is generally authorized to operate the reservoir to meet the association's goal of providing an adequate supply of irrigation water to met contracts with water users without exceeding safe storage and flow levels.

The dam operator's specific responsibilities are to:

1. Operate the mechanical features of the outlet works.
2. Coordinate filling the reservoir and releasing the water.
3. Notifying the SWPB of any unusual occurrences such as impending floods, excessive seepage, and if the spillway is flowing.
4. Perform various maintenance tasks.
5. Maintain water level records and report findings to the SWPB.
6. Monitor weather conditions.
7. Monitor seepage.

Typically, the out-going dam operator, the association, and the SWPB train a new dam operator. The dam operator's training focuses on the mechanical operation of the gates, measurement of the storage level, measurement of the rate of water release, and record keeping. The outlet gates are operated manually with a hand crank.

The outlet works are used for controlling the release of irrigation water and not for providing emergency relief. If the outlet works are operated for emergency relief beyond the capacity of the outlet canals, the canals and the structures below the dam would be damaged.

The dam operator is normally available daily to observe the dams and perform operating functions during the filling and irrigation seasons, and is available at other times of the year. Communication among the dam operator, the association, and the SWPB usually takes place by telephone. Although radio communications are not routinely available, during emergencies or unusual occurrences, radio communications may be established so the dam operator can speak directly with county authorities and with the SWPB **(see Nilan Reservoir East Dam and North Dam Emergency Plan)**.

STORAGE DETERMINATION

Storage in the reservoir and the elevation of the reservoir surface are determined by taking a slope measurement. Measure in feet from the steel post, located in a concrete pad on the reservoir side of the parking lot on the south side of the East Dam, to the water surface. The elevation of the reservoir surface and the storage can then be found using the Slope-Elevation-Storage Table (Table 1) in Appendix A.

When the reservoir is at or below 3,271 acre-feet, the alternate slope line must be used. The 0+00 pin is located 92.6 feet from the southeast corner of the gatehouse, and over the outlet tunnel.

If water is not being diverted, storage and reservoir surface elevation can be determined by measuring from the top of the grill in the gatehouse to the water surface. The top of grill elevation is 4,452.0 feet. Subtract the vertical distance from the grill to the water surface from 4,452.0 to find the elevation of the water surface. Once the reservoir surface elevation is determined, the reservoir storage is found using the Elevation/Storage Table (Table 2) in Appendix A.

WEATHER MONITORING

The dam operator monitors weather conditions through local weather forecasts and the National Weather Service.

If severe flooding is anticipated, the NWS Great Falls Office (406-453-2081 or 406-453-4561) should be contacted for information about the storm, such as the estimated storm intensity and duration, runoff duration (above base flow), and total flood volume of the storm in the Willow Creek and Elk Creek drainages.

INTERACTION WITH OTHER DAMS

Willow Creek Dam and Reservoir is approximately 6 miles downstream from the Nilan North Dam. Greenfields Irrigation District operates Willow Creek Dam. The safety of Willow Creek Dam is not affected by the North Dam during normal operations

The town of Augusta is approximately 9 miles downstream from the Nilan East Dam. The safety of the town of Augusta is not affected by the by either of the East or North Dams during normal operation.

There are no dams below the Nilan East Dam and no dams upstream of Nilan Reservoir.

EMERGENCY

If it appears that either one or both of the Nilan Dams is about to breach, or during emergency operations, the dam operator will initiate the **Nilan Reservoir East Dam and North Dam Emergency Action Plan**.

The Town of Augusta is likely to begin flooding approximately 1.8 hours after a breach of the Nilan East Dam and approximately 3.9 hours after the failure of the North Dam. Therefore, if it appears that either dam will breach, the dam operator will initiate the Emergency Alert System which is described on page 21 of the **Nilan Reservoir East Dam and North Dam Emergency Action Plan.**

If the North Dam breaches, at least 10,000 cfs would be routed through Willow Creek Dam. Under such an emergency, the safety of Willow Creek Dam could be jeopardized. Therefore, if it appears the North Dam will breach, the dam operator should immediately notify Mr. Ed Everaert, manager of the Greenfields Irrigation District (**office: 406-467-2533, home 406-467-3342**).

INSPECTION AND MONITORING

The SWPB inspects the dams annually. Appendix B includes an example of a SWPB inspection report form. In addition to annual inspections, SWPB personnel will inspect the dams and reservoir during and after heavy runoff, severe rainstorms, and severe windstorms; during high storage periods; and after an earthquake. Both dams have monitoring wells and weirs.

STRUCTURAL FEATURES INSPECTION

Structural features include the gatehouses, spillway, and outlet works. The SWPB will inspect these structures annually as part of its inspection program. Items checked or noted include, but are not limited to:

1. Outlet Works
    1. Any differential settlement or movement resulting in cracking of the conduits.
    2. Erosion of the seals or the conduits by cavitation immediately downstream of the gates
    3. Major seepage of water into the conduits.
    4. Major deterioration of exposed concrete due to freeze/thaw cycles or sulfate reactions.
    5. Operation of the gates through a full cycle.
    6. Corrosion of any metal.
    7. Lubrication and cleaning of the pedestals.
    8. Air vents for unobstructed flow.
2. Gatehouses -- Any damage or vandalism.
3. Spillway
    1. Erosion of the spillway channel.
    2. Blockage of the approach.
    3. Deterioration of concrete.

4. Toe Area Upstream of Both Dams
   Inspect for the development of sinkholes when the area is exposed.

RIPRAP INSPECTION

The riprap along the face of each dam should be at least 30 inches thick. Immediately after the occurrence of high water, the riprap will be inspected and additional riprap added if needed.

DRAINS

East Dam: There are no known internal drains at the East Dam.

North Dam: There are two toe drainpipes that exit into each side of the outlet channel, approximately 25 feet downstream of the outlet. These two drains are not shown on any of the design drawings for the North Dam. The COE Phase I Inspection Report, July 1981, reported that a May 18, 1953 report commented about some seepage and extending the right drain by 25 feet and constructing an additional drain on the flat below the hill. This indicates that the drains were part of the original construction of the dam. The flow in the drains varies depending upon the reservoir elevation. In 1999, the water users built a fence around the area to keep cattle from damaging the drainpipes and the toe of the dam.

MONITORING WELLS

At the East Dam, seven monitoring wells were installed in the spring of 1999 -- five along the dam crest and two along the downstream toe. An additional monitoring well was installed along the downstream toe in the fall, 1999. Two more monitoring wells were added along the downstream toe in the fall of 2000. In addition, there are four shallow hand-driven "Beck" type piezometers at the toe of the dam around the outlet structure which were installed in 1997 and 1998.

At the North Dam, seven monitoring wells were installed in the fall of 1999 -- three along the dam crest and four along the downstream toe. Generally, two piezometers were installed in each monitoring well. In addition, there are four shallow hand-driven "Beck" type piezometers at the toe of the dam around the outlet structure which were installed in 1997.

Figures 4 and 5 show the general location of these monitoring wells. Soil profiles of the drill holes and details as to how the wells were constructed are shown in Appendix D.

SEEPAGE MONITORING

Both dams at Nilan Reservoir show seepage. At the North Dam, the seepage is primarily in the toe area around the outlet channel headwalls. Swampy conditions exist throughout this area. The seepage is estimated at 1 to 2 gpm, but is not measurable. Above the left drain is another seep area which is monitored with a v-notch weir. See V-notch weir discharge table in Appendix A.

At the East Dam, seepage has been observed exiting along the right outlet wing wall, but is not measurable. Seepage also exits from the left abutment, and is measured with a v-notch weir on the downstream side of the county road. There is also a seepage area, approximately 70 feet in length, along the left side of the canal about 50 feet downstream the outlet structure.

The monitoring wells, seepage areas, drains and weirs at the dams are observed and monitored by the dam operator, DNRC

Helena Regional Office, and SWPB during regular visits; and may be measured by the SWPB during annual inspections. The instruments are generally measured twice per month from May 1 to August 31, and once per month in March, April, September, and October. Measurements may be taken during the winter months (November, December, January, February) depending on weather conditions. The monitoring data is maintained by the SWPB in Helena.

MAINTENANCE

The association is responsible for routine maintenance of the project. In addition, the SWPB may identify items that need maintenance or repair during the annual inspection.

ROUTINE MAINTENANCE

To protect the dam and keep it in good working order, the dam operator during regular visits to the dam will watch for and identify any potential maintenance requirements. As soon as a need is identified, the dam operator needs to schedule and perform the routine maintenance.

Items that may occasionally need attention include, but are not limited to:

1. *Lubrication of gate-operating mechanisms and keep the gate house and pedestals clean.*
2. *Debris or silt restricting the supply canals, spillway inlet or the outlet works.* Accumulated debris that could affect the operation of these appurtenances will be removed at once, with all debris removed at least annually.
3. *Erosion gullies on embankments.* Development of erosion gullies will be checked immediately. Gullies will be filled, compacted, and seeded. Particular attention will be paid to the abutment contact areas and the downstream faces where four-wheel drive tracks may become a problem.
4. *Rodent damage.* The rodents will be removed or destroyed, and any burrows holes should be filled immediately.
5. *Upstream slope riprap.* The upstream riprap of both dams and dike normally will be observed annually, but may occasionally need repairs because of high water or wave action.
6. *Vegetative cover on downstream slopes.* Good vegetative cover will be maintained, but large brush will be removed.

7. *Air vent.* The east dam has an air vent which sometimes gets covered inadvertently by the road maintenance crew. The air vent needs to be kept open.
8. *Noxious Weeds.* Noxious weeds on and around the dam embankments, dike, reservoir, and canals should be sprayed on at least as annual basis.
9. *Cleaning spillway and outlet structure wall tops.* The spillway and outlet structure wall tops should be clear of any dirt, rocks, grass, brush, and any overhanging vegetation or trees.
10. *Weirs.* These devices will be maintained clean of sediment and algae, kept upright, free flowing, and free of debris.

ANNUAL MAINTENANCE

The SWPB conducts annual inspections of the Nilan Dams and Reservoir. During these inspections, any items requiring annual maintenance will be identified and recorded. Items that may need annual maintenance include the spillway, outlet works, gates, riprap and gatehouses. Any other routine items that need immediate attention, such as removing trees or brush, will also be noted.

After the inspection the SWPB sends the association a Dam Safety Inspection Report and a Maintenance Schedule Report. The reports identify items that need maintenance and provides a schedule of when the maintenance tasks need to be completed. The association is responsible for performing the maintenance items within the times specified.

The dam operator or association members may perform the maintenance tasks. However, major repairs will likely be handled by a contractor. The SWPB may assist in contracting for repairs and may supervise the work.

RECORD KEEPING

The SWPB will maintain records, including photographs, of all inspections, and maintenance requirements. These records also include seepage monitoring observations. Anyone who wants to review these records may so in the SWPB's office at the Department of Natural Resources and Conservation in Helena, Montana.

The dam operator will keep records of the reservoir elevation, seepage observations or measurements, and any unusual conditions. These records may be reviewed at the dam operators house.

REFERENCES

U.S. Army Corps of Engineers. July 1981. Phase One Inspection Report, National Dam Safety Program, Elk Creek Basin, Nilan East Dam, MT-14, Willow Creek Basin, Nilan North Dam, MT-3206, Augusta, Montana. Prepared for the State of Montana (DNRC) by Morrison-Maierle, Inc. under the U.S. Army Corps of Engineers Nation Dam Safety Program.

Artz, Bert, Nilan Dam Operator: September 1993 and February 1994.

Personal telephone conversation and meeting with Marvin Cross, Havre Regional Office Civil Engineering Specialist, Water Resources Division, DNRC, Havre.

Parish, Lovell, Regional Geologist. 1998. Geotechnical Inspection of Nilan East and Nilan North Dam and Dike - Lewis and Clark County , Montana. Prepared for the State of Montana (DNRC) by the Bureau of Reclamation, Great Plains Office, Billings Regional Office, Montana.

APPENDICES

APPENDIX A

RATING CURVES AND TABLES

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE
NILAN RESERVOIR

Pins installed and elevations established with a level on 10/3/2000.
The 0+00 pin is at the base of the steel post in the concrete pad which is on the reservoir side of the parking area just west of the right (southwest) end of the dam.
The alignment is slightly right of the previous line and terminates in a depression which will go dry to the north at 4426.88 ft of elevation and to the west at 4424.33 ft of elevation.
One pin was installed for an alternate slope below the gatehouse. See notes in table on page A4.
Storage volumes from the 7/1997 slope pin table.

DISTANCE	ELEVATION	STORAGE
0+00 IS THE BASE OF THE STEEL POST IN THE CONCRETE PAD	4451.20	15,112
1	4451.03	15,015
2	4450.85	14,907
3	4450.68	14,812
4	4450.51	14,716
5	4450.34	14,618
6	4450.16	14,515
7	4449.99	14,415
8	4449.82	14,319
9	4449.64	14,215
10	4449.47	14,117
11	4449.24	13,986
12	4449.02	13,859
13	4448.79	13,726
14	4448.56	13,594
15	4448.34	13,467
16	4448.11	13,336
17	4447.88	13,203
18	4447.65	13,071
19	4447.43	12,944
20	4447.20	12,812
21	4447.01	12,703
22	4446.82	12,594
23	4446.62	12,479
24	4446.43	12,370
25	4446.24	12,260
26	4446.05	12,151
27	4445.86	12,041
28	4445.66	11,926
29	4445.47	11,818
30	4445.28	11,708
31	4445.13	11,622
32	4444.98	11,536
33	4444.84	11,455
34	4444.69	11,369
35	4444.54	11,282
36	4444.39	11,197
37	4444.24	11,111
38	4444.10	11,030
39	4443.95	10,943
40	4443.80	10,857
41	4443.68	10,788
42	4443.55	10,713
43	4443.43	10,645
44	4443.31	10,576
45	4443.18	10,501
46	4443.06	10,432
47	4442.94	10,360
48	4442.81	10,281
49	4442.69	10,208
50	4442.57	10,135
0+50 CAP	4442.56	10,129
SPILLWAY	4442.50	10,092
51	4442.48	10,080
52	4442.39	10,025
53	4442.30	9,970
54	4442.21	9,915
55	4442.12	9,860
56	4442.04	9,811
57	4441.95	9,762
58	4441.86	9,716
59	4441.77	9,671
60	4441.68	9,625
61	4441.58	9,575
62	4441.48	9,524
63	4441.38	9,474
64	4441.27	9,418
65	4441.17	9,368
66	4441.07	9,317
67	4440.97	9,267
68	4440.87	9,218
69	4440.77	9,169
70	4440.67	9,120
DISTANCE	ELEVATION	STORAGE

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)
NILAN RESERVOIR

DISTANCE	ELEVATION	STORAGE
71	4440.50	9,037
72	4440.33	8,954
73	4440.17	8,875
74	4440.00	8,792
75	4439.84	8,716
76	4439.67	8,635
77	4439.50	8,554
78	4439.34	8,464
79	4429.17	8,398
80	4439.00	8,317
81	4438.91	8,276
82	4438.81	8,230
83	4438.71	8,184
84	4438.62	8,142
85	4438.52	8,096
86	4438.42	8,050
87	4438.33	8,009
88	4438.23	7,963
89	4438.13	7,917
90	4438.04	7,875
91	4437.98	7,848
92	4437.92	7,821
93	4437.86	7,794
94	4437.80	7,767
95	4437.74	7,740
96	4437.68	7,713
97	4437.63	7,690
98	4437.57	7,664
99	4437.51	7,637
100	4437.45	7,610
1+00 CAP	4437.41	7,592
101	4437.41	7,592
102	4437.36	7,569
103	4437.32	7,551
104	4437.27	7,528
105	4436.89	7,359
106	4436.50	7,187
107	4436.11	7,015
108	4436.01	6,971
109	4435.92	6,933
110	4435.82	6,890
111	4435.66	6,822
112	4435.50	6,754
113	4435.34	6,686
114	4435.18	6,618
115	4435.02	6,550
116	4434.86	6,484
117	4434.70	6,417
118	4434.54	6,351
119	4434.38	6,285
120	4434.22	6,218
121	4434.06	6,152
122	4433.90	6,087
123	4433.74	6,025
124	4433.58	5,961
125	4433.42	5,898
126	4433.26	5,834
127	4433.10	5,771
128	4432.94	5,710
129	4432.78	5,648
130	4432.62	5,591
131	4432.41	5,514
132	4432.20	5,436
133	4432.00	5,362
134	4431.79	5,290
135	4431.58	5,217
136	4431.38	5,156
137	4431.17	5,075
138	4430.96	5,004
139	4430.76	4,941
140	4430.54	4,872
141	4430.33	4,806
142	4430.12	4,739
143	4429.91	4,675
144	4429.70	4,612
145	4429.48	4,546
146	4429.27	4,483
147	4429.06	4,420
148	4428.85	4,357
149	4428.64	4,294
150	4428.43	4,232
1+50 CAP	4428.28	4,187
151	4428.20	4,163
152	4427.98	4,097
153	4427.76	4,033
154	4427.54	3,970
155	4427.32	3,906
156	4427.10	3,842
157	4426.88	3,778
158	4426.66	3,714
DISTANCE	ELEVATION	STORAGE

TABLE 1. SLOPE-ELEVATION-STORAGE TABLE (continued)

NILAN RESERVOIR

DISTANCE	ELEVATION	STORAGE	DISTANCE	ELEVATION	STORAGE
159	4426.44	3,651	171	4425.35	3,341
160	4426.22	3,587	172	4425.32	3,333
161	4426.13	3,561	173	4425.29	3,324
162	4426.04	3,535	174	4425.27	3,319
163	4425.95	3,509	175	4425.24	3,310
164	4425.86	3,478	176	4425.21	3,302
165	4425.77	3,459	177	4425.18	3,293
166	4425.68	3,433	178	4425.16	3,288
167	4425.58	3,405	179	4425.13	3,279
168	4425.49	3,380	180	4425.10	3,271
169	4425.40	3,355			
170	4425.38	3,349			
DISTANCE	ELEVATION	STORAGE	DISTANCE	ELEVATION	STORAGE

ALTERNATE SLOPE LINE BELOW GATE HOUSE

The A0+00 pin is 92.6 feet from the southeast corner of the gatehouse, and over the outlet tunnel. There is 0.36 feet of vertical water surface drop that is not covered between the two tables

DISTANCE	ELEVATION	STORAGE	DISTANCE	ELEVATION	STORAGE
A0+00 CAP	4424.74	3,173	16	4420.99	2,272
1	4424.44	3,092	17	4420.69	2,212
2	4424.15	3,014	18	4420.39	2,149
3	4423.86	2,938	19	4420.09	2,086
4	4423.56	2,865	20	4419.79	2,028
5	4423.27	2,794	21	4419.35	1,945
6	4423.09	2,750	22	4418.91	1,864
7	4422.90	2,705	23	4418.47	1,785
8	4422.72	2,664	24	4418.03	1,705
9	4422.53	2,620	25	4417.59	1,630
10	4422.35	2,579	26	4417.04	1,537
11	4422.13	2,528	27	4416.49	1,448
12	4421.92	2,480	28	4415.94	1,361
13	4421.71	2,434	29	4415.39	1,278
14	4421.50	2,387	30	4414.84	1,198
15	4421.29	2,341			
DISTANCE	ELEVATION	STORAGE	DISTANCE	ELEVATION	STORAGE

TABLE 2. ACTIVE STORAGE IN ACRE-FEET

NILAN RESERVOIR

ELEV	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
4,401	0	3	6	9	12	15	18	21	24	27
4,402	30	34	39	43	48	52	57	61	66	70
4,403	75	80	86	91	97	102	108	113	119	124
4,404	130	136	143	149	156	162	168	175	181	188
4,405	194	201	207	214	220	227	234	240	247	253
4,406	260	268	276	284	292	300	308	616	324	332
4,407	340	349	358	367	376	385	394	403	412	421
4,408	430	439	449	458	468	477	487	496	506	515
4,409	525	534	544	554	563	573	583	592	602	611
4,410	621	631	641	651	661	670	680	690	700	710
4,411	720	731	742	753	764	775	786	797	808	819
4,412	830	842	854	866	878	890	902	914	926	938
4,413	950	963	976	989	1,002	1,015	1,028	1,041	1,054	1,067
4,414	1,080	1,094	1,108	1,122	1,136	1,150	1,164	1,178	1,192	1,206
4,415	1,220	1,235	1,250	1,265	1,280	1,295	1,310	1,325	1,340	1,355
4,416	1,370	1,386	1,402	1,418	1,434	1,450	1,466	1,482	1,498	1,514
4,417	1,530	1,547	1,564	1,581	1,598	1,615	1,632	1,649	1,666	1,683
4,418	1,700	1,718	1,736	1,754	1,772	1,790	1,808	1,826	1,844	1,862
4,419	1,880	1,899	1,917	1,936	1,955	1,973	1,992	2,011	2,030	2,048
4,420	2,067	2,088	2,109	2,130	2,151	2,172	2,193	2,214	2,235	2,256
4,421	2,277	2,299	2,321	2,343	2,365	2,387	2,410	2,432	2,454	2,476
4,422	2,498	2,521	2,544	2,567	2,590	2,613	2,636	2,659	2,682	2,705
4,423	2,728	2,752	2,777	2,801	2,825	2,850	2,875	2,899	2,924	2,948
4,424	2,973	3,000	3,027	3,054	3,081	3,108	3,135	3,162	3,189	3,216
4,425	3,243	3,271	3,299	3,327	3,355	3,383	3,411	3,439	3,467	3,495
4,426	3,523	3,552	3,581	3,610	3,639	3,668	3,697	3,726	3,755	3,784
4,427	3,813	3,842	3,871	3,900	3,929	3,958	3,987	4,016	4,045	4,074
4,428	4,103	4,132	4,163	4,193	4,223	4,252	4,282	4,312	4,342	4,372
4,429	4,402	4,432	4,462	4,492	4,522	4,552	4,582	4,612	4,642	4,672
4,430	4,702	4,733	4,765	4,796	4,828	4,859	4,891	4,922	4,954	4,985
4,431	5,017	5,051	5,086	5,120	5,155	5,189	5,224	5,258	5,293	5,327
4,432	5,362	5,399	5,436	5,473	5,510	5,547	5,584	5,621	5,658	5,695
4,433	5,732	5,771	5,811	5,850	5,890	5,929	5,969	6,008	6,048	6,087
4,434	6,127	6,168	6,210	6,251	6,293	6,334	6,376	6,417	6,459	6,500
4,435	6,542	6,584	6,627	6,669	6,712	6,754	6,797	6,839	6,882	6,924
4,436	6,967	7,011	7,055	7,099	7,143	7,187	7,231	7,275	7,319	7,363
4,437	7,407	7,452	7,497	7,542	7,587	7,632	7,677	7,722	7,767	7,812
4,438	7,857	7,903	7,949	7,995	8,041	8,087	8,133	8,179	8,225	8,271
4,439	8,317	8,364	8,412	8,459	8,507	8,554	8,602	8,649	8,697	8,744
4,440	8,792	8,841	8,890	8,939	8,988	9,037	9,086	9,135	9,184	9,233
4,441	9,282	9,332	9,383	9,433	9,484	9,534	9,585	9,635	9,686	9,736
4,442	9,787	9,848	9,909	9,970	10,031	10,092	10,153	10,214	10,275	10,366

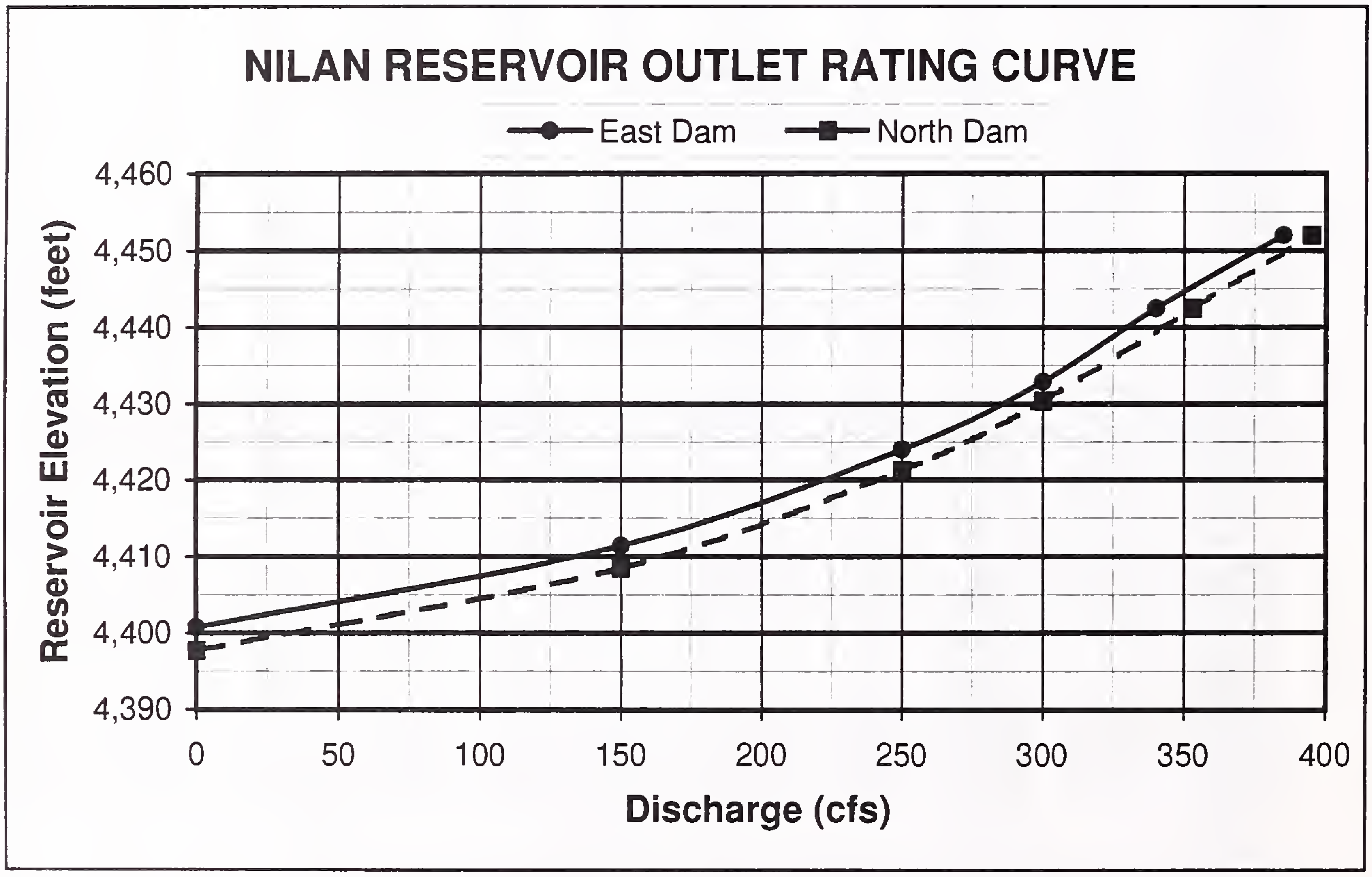
NOTE: Storage table based on 1938 original hand surveys of the reservoir.

Spillway Crest Elevation	4,442.5 feet
Top of Grill in Gatehouse	4,452.0 feet
Top of Dam Crest	4,452.0 feet

TABLE 3. OUTLET DISCHARGE

NILAN RESERVOIR

East Dam			North Dam	
Reservoir Elevation (feet)	Discharge (cfs)		Reservoir Elevation (feet)	Discharge (cfs)
4,400.75	0		4,397.75	0
4,411.40	150		4,408.50	150
4,424.00	250		4,421.30	250
4,432.90	300		4,430.40	300
4,442.50	340	Spillway Crest	4,442.50	353
4,452.00	385	Dam Crest	4,452.00	395

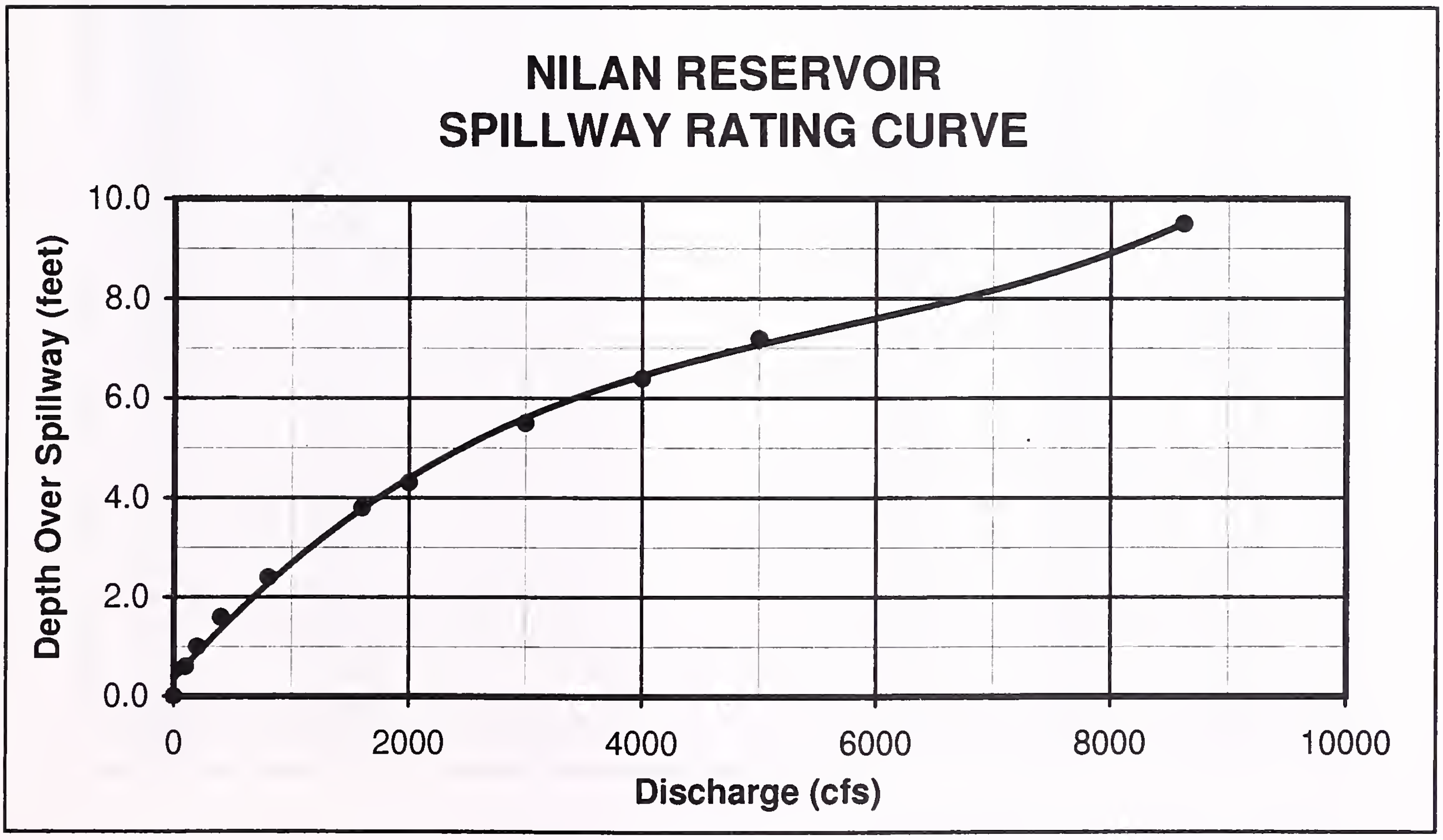


Notes: Discharge assumes operating gate is completely open.
Data from the Corps of Engineers Phase 1 Inspection Report (1981).

TABLE 4. SPILLWAY DISCHARGE

NILAN RESERVOIR

Depth Over Crest (feet)	Elevation (feet)	Discharge (cfs)
0.0	4,442.5	0
0.6	4,443.1	100
1.0	4,443.5	200
1.6	4,444.1	400
2.4	4,444.9	800
3.8	4,446.3	1,600
4.3	4,446.8	2,000
5.5	4,448.0	3,000
6.4	4,448.9	4,000
7.2	4,449.7	5,000
9.5	4,452.0	8,620



Note: Data from the Corps of Engineers Phase 1 Inspection Report (1981).

TABLE 5. V-NOTCH WEIR RATING TABLE

HEAD	DISCHARGE			HEAD	DISCHARGE	
(IN)	(GPM)	(CFS)		(IN)	(GPM)	(CFS)
---------	---------	---------		4.1	77.8	0.173
---------	---------	---------		4.2	82.6	0.184
---------	---------	---------		4.3	87.5	0.195
---------	---------	---------		4.4	92.6	0.206
0.5	0.4	0.001		4.5	98.0	0.218
0.6	0.7	0.001		4.6	103.4	0.230
0.7	1.0	0.002		4.7	109.1	0.243
0.8	1.4	0.003		4.8	115.0	0.256
0.9	1.8	0.004		4.9	121.0	0.270
1.0	2.4	0.005		5.0	127.2	0.283
1.1	3.0	0.007		5.1	133.6	0.298
1.2	3.7	0.008		5.2	140.2	0.312
1.3	4.5	0.010		5.3	147.0	0.328
1.4	5.4	0.012		5.4	154.0	0.343
1.5	6.4	0.014		5.5	161.2	0.359
1.6	7.5	0.017		5.6	168.5	0.375
1.7	8.8	0.020		5.7	176.1	0.392
1.8	10.1	0.022		5.8	183.8	0.410
1.9	11.5	0.026		5.9	191.8	0.427
2.0	13.1	0.029		6.0	199.9	0.445
2.1	14.8	0.033		6.1	208.3	0.464
2.2	16.6	0.037		6.2	216.9	0.483
2.3	18.5	0.041		6.3	225.6	0.503
2.4	20.6	0.046		6.4	234.6	0.523
2.5	22.8	0.051		6.5	243.8	0.543
2.6	25.1	0.056		6.6	253.2	0.564
2.7	27.6	0.061		6.7	262.9	0.586
2.8	30.2	0.067		6.8	272.7	0.608
2.9	32.9	0.073		6.9	282.8	0.630
3.0	35.8	0.080		7.0	293.0	0.653
3.1	38.9	0.087		7.1	303.5	0.676
3.2	42.1	0.094		7.2	314.2	0.700
3.3	45.4	0.101		7.3	325.2	0.725
3.4	48.9	0.109		7.4	336.3	0.749
3.5	52.5	0.117		7.5	347.7	0.775
3.6	56.3	0.126		7.6	359.3	0.801
3.7	60.3	0.134		7.7	371.2	0.827
3.8	64.4	0.144		7.8	383.2	0.854
3.9	68.7	0.153		7.9	395.5	0.881
4.0	73.1	0.163		8.0	408.1	0.909

$Q = (2.49\,(H/12)^{2.48})(448.83)$

Q in gpm

H in inches

APPENDIX B.

INSPECTION REPORT FORM

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION
DAM SAFETY INSPECTION REPORT

NAME OF DAM ____________
DATE INSPECTED___________

INVENTORY NO. ______________
HAZARD CATEGORY __________
TYPE OF DAM ________________
YEAR BUILT __________________

OWNER ______________________
OPERATOR ___________________
STREAM ______________________
DRAINAGE AREA _____________

Reservoir Storage Status

	Water Surface Elevation (feet)	Storage (acre-feet)
At time of inspection	_________	_______
At spillway crest	_________	_______
At min. dam crest elevation	_________	_______

ITEM	YES	NO	REMARKS

1. EMBANKMENT

A. Crest -- Height= Length= Width=

(1) Any visual settlements?			
(2) Any misalignments?			
(3) Any cracking?			
(4) Any traffic damage?			
(5) Other?			

ITEM	YES	NO	REMARKS

1. **EMBANKMENT** (continued)

B. Upstream Face -- Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Is riprap protection adequate?			
(5) Any stone deterioration?			
(6) Any visual settlement, slumps, sloughing, depressions or bulges?			
(7) Adequate grass cover?			
(8) Debris on the dam face?			
(9) Other?			

C. Downstream Face--Slope=

(1) Any erosion?			
(2) Any longitudinal cracks?			
(3) Any transverse cracks?			
(4) Any visual settlement, slumps, sloughing, depressions or bulges?			
(5) Is the toe drain dry?			
(6) Are the relief wells flowing?			
(7) Any boils at the toe?			
(8) Any seepage areas?			
(9) Any traffic or animal damage?			
(10) Any burrowing animals?			
(11) Adequate grass cover?			
(12) Other?			

D. Amount and Type of Vegetation on the Dam

ITEM	YES	NO	REMARKS

2. ABUTMENT CONTACTS

A) Any erosion?			
B) Any visual differential movement?			
C) Any cracks?			
D) Any seepage present?			
E) Other?			

3. OUTLET WORKS

A. Intake Structure -- Size=

(1) Any settlement?			
(2) Any tilting?			
(3) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(4) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(5) Metal appurtenances:			
a. Any corrosion present?			
b. Any breakage present?			
(6) Trash rack?			
a. Condition?			
b. Anchor system secure?			
(7) Other?			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

B. Conduit -- Type = Size =

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Is the conduit metal?			
a. Any corrosion present?			
b. Protective coatings adequate?			
(4) Is the conduit misaligned?			
(5) Any calcium deposits?			
(6) Other?			

C. Gates and Tower

(1) Gates:			
a. Size: Operating: Emergency: b. Type: Operating: Emergency:			
(2) Controls operational?			
(3) Controls lubricated?			
(4) Operational problems?			
(5) Leakage around gates?			
(6) Condition of gate seals?			
(7) Any cavitation damage? If so, describe?			
(8) Describe air vent-size and condition.			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

C. Gates and Tower (continued)

(9) Is there a jet pump?			
a. Is it operational?			
b. Leakage?			
(10) Is the tower dry? _____ wet? __			
(11) Any seepage in the tower?			
(12) Condition of the tower?			
(13) Any safety problems?			
(14) Ladder in good condition?			
(15) Condition of the gatehouse?			
(16) Emergency plan completed for the dam?			
a. Posted in the gatehouse?			
(17) Other?			

D. Stilling Basin

(1) Do concrete surfaces show:			
a. Spalling?			
b. Cracking?			
c. Erosion?			
d. Exposed reinforcement?			
(2) Do joints show:			
a. Displacement or offset?			
b. Loss of joint material?			
c. Leakage?			
(3) Do energy dissipaters show:			
a. Signs of deterioration?			
b. Are they covered with debris?			
(4) Other?			

ITEM	YES	NO	REMARKS

3. OUTLET WORKS (continued)

E. Downstream Channel

(1) Is the channel:			
a. Eroding or backcutting?			
b. Sloughing?			
c. Obstructed?			
(2) Is released water:			
a. Undercutting the outlet?			
b. Eroding the embankment?			
(3) Other?			

4. SPILLWAY

A. Description

(1) Location?			
(2) Type of Spillway?			
(3) Size of Spillway?			
(4) Spillway lining?			
(5) Is there a weir?			
(6) Is the spillway in good condition?			
(7) Any drains?			
a. Describe the condition of drains.			

B. Does spillway show:

(1) Any cracking concrete?			
(2) Any spalling concrete?			
(3) Any exposed reinforcement in the concrete?			
(4) Any erosion?			

ITEM	YES	NO	REMARKS

4. SPILLWAY (continued)

4. B. Does spillway show: (continued)

(5) Any slope sloughing?			
(6) Any obstructions?			
(7) Displacement or offset joints?			
(8) Loss of joint material?			
(9) Leakage at the joints?			
(10) Other?			

C. Do the energy dissipaters show:

(1) Signs of deterioration?			
(2) Any cracking?			
(3) Any spalling?			
(4) Any exposed reinforcement?			
(5) Are they covered with debris?			
(6) Other?			

D. Has release water:

(1) Eroded the embankment?			
(2) Undercut the outlet?			
(3) Eroded the downstream channel?			
(4) Other?			

E. Emergency Spillway

(1) Is there an emergency spillway?			(If YES, describe)

ITEM	YES	NO	REMARKS

5. RESERVOIR CONTROL

A) Recent upstream development?			
B) Recent downstream development?			
C) Slides in reservoir area?			
D) Change in reservoir operation?			
E) Large impoundment upstream?			
F) Any debris in the reservoir?			
G) Other?			

6. INSTRUMENTATION

A) List type(s) of instrumentation:			
B) In good condition?			
C) Read periodically?			
D) Is data available?			
E) Include all data gathered since last report.			

7. DOWNSTREAM CONDITION

A. Downstream Land Use.

This dam was inspected by:

Additional comments and recommendations.

APPENDIX C

DISTRIBUTION LIST

NILAN RESERVOIR DAMS O&M DISTRIBUTION LIST

	Number Of Copies
1. State Water Projects Bureau	7
Glen McDonald	
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2. DNRC Information Services Section	1
3. DNRC Regional Office	1
Jim Beck	
4. Dam Safety	1
5. Water Users	3
Richard Artz -- President	
Lloyd J. Allen -- Vice President	
Barbara Buckley -- Secretary	
6. Dam Operator	3
Dam Operator (Bert Artz)	
Gate Houses (2)	
7. State Library -- Attn: Roberta Gebhardt	4
8. Extra	2
TOTAL	22

APPENDIX D

MONITORING WELL LOGS

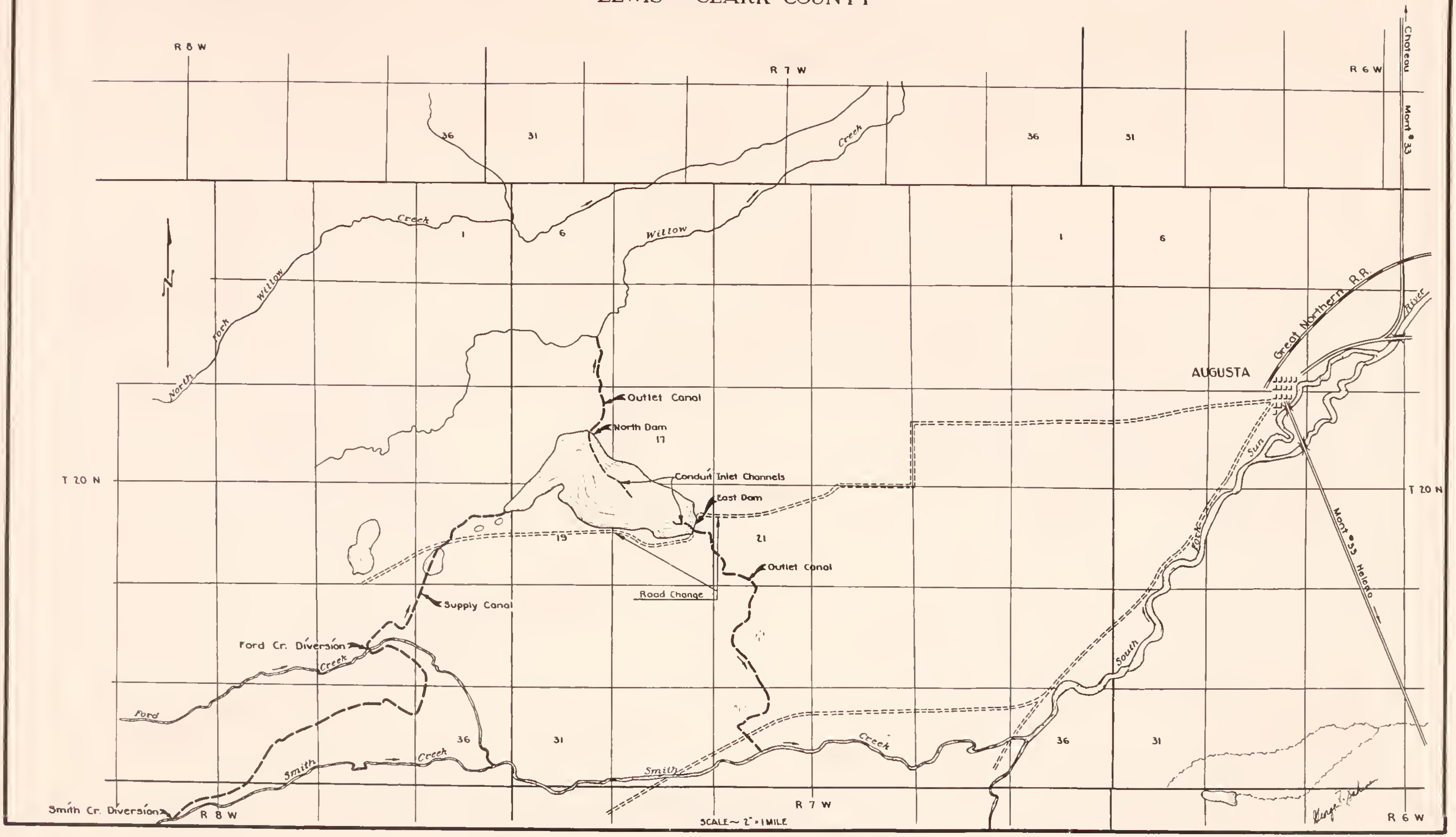
(NOTE: The soil profile logs for the drill holes and details as to how the wells were constructed have not been prepared as of this printing. The soil profile and well completion logs will be added in the future when they are prepared.)

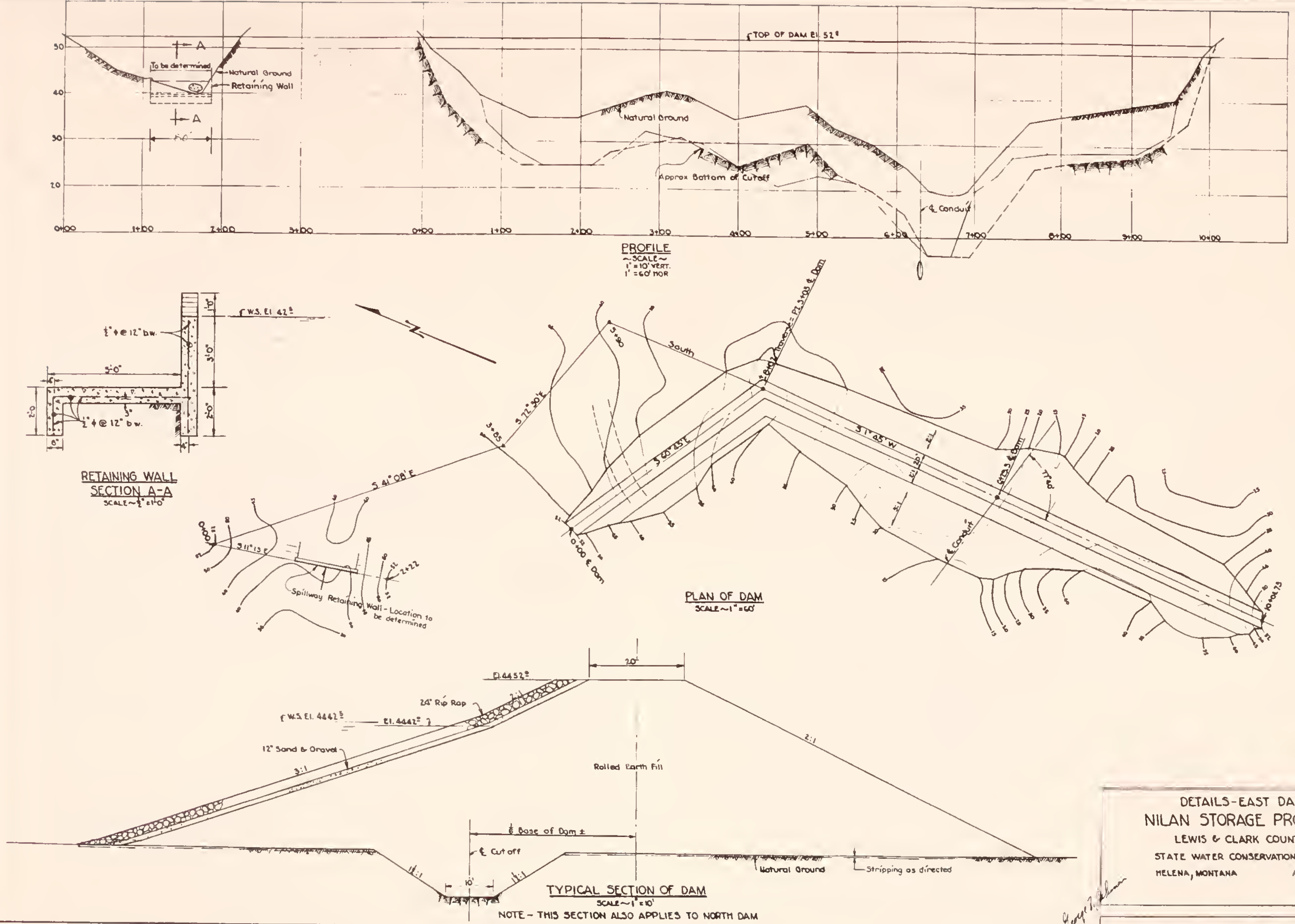
APPENDIX E

PROJECT DRAWINGS

(NOTE: These reduced project drawings are design drawings and not "As Builts". These drawing should be used for reference only. The SWPB has the full size project drawings.)

MONTANA WATER CONSERVATION BOARD
NILAN STORAGE PROJECT
LEWIS & CLARK COUNTY





PROFILE
~SCALE~
1" = 10' VERT.
1" = 60' HOR

RETAINING WALL
SECTION A-A
SCALE ~ 1/2" = 1'-0"

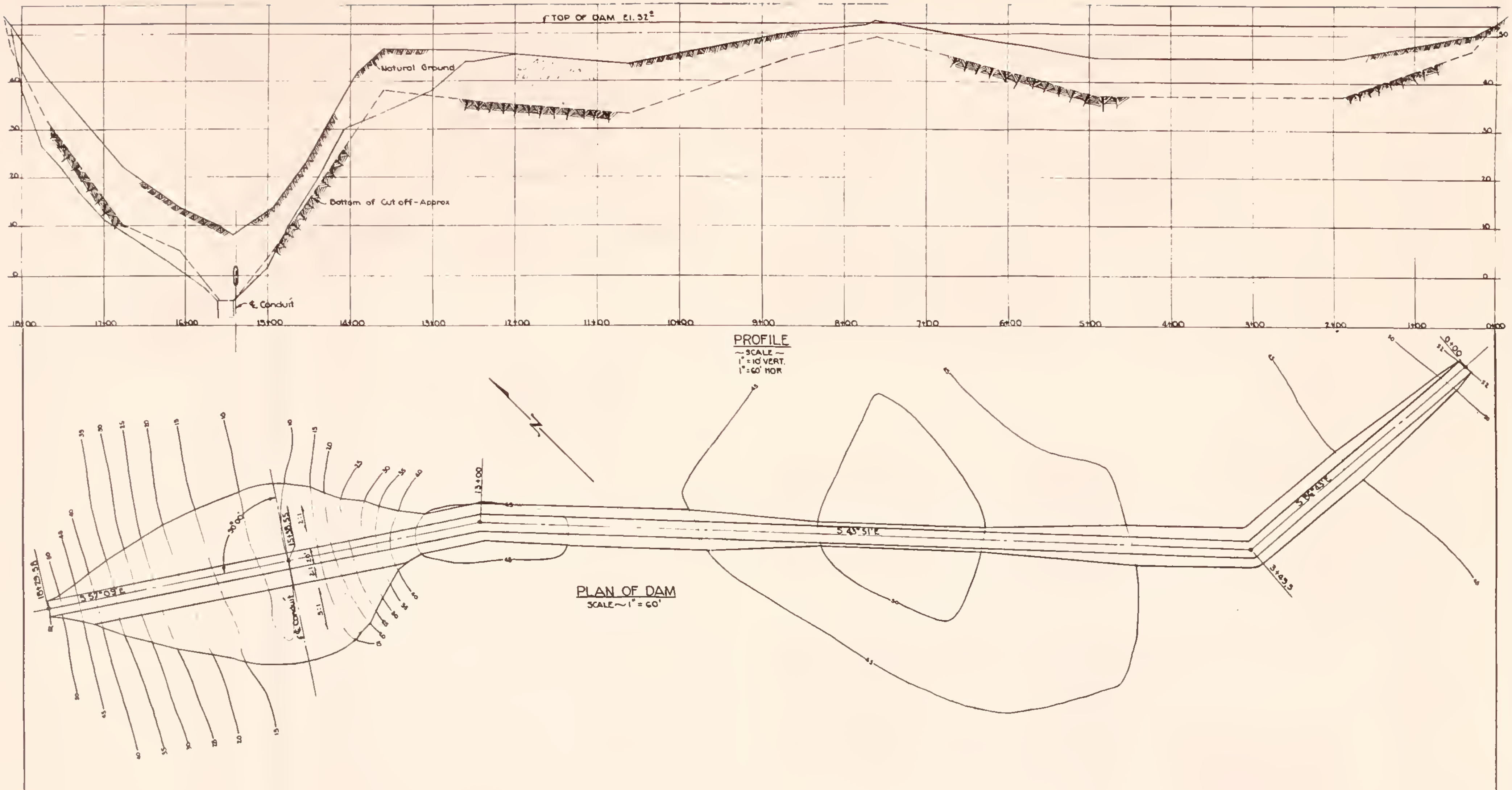
PLAN OF DAM
SCALE ~ 1" = 60'

TYPICAL SECTION OF DAM
SCALE ~ 1" = 10'
NOTE - THIS SECTION ALSO APPLIES TO NORTH DAM

DETAILS-EAST DAM
NILAN STORAGE PROJECT
LEWIS & CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA AUG. 1950

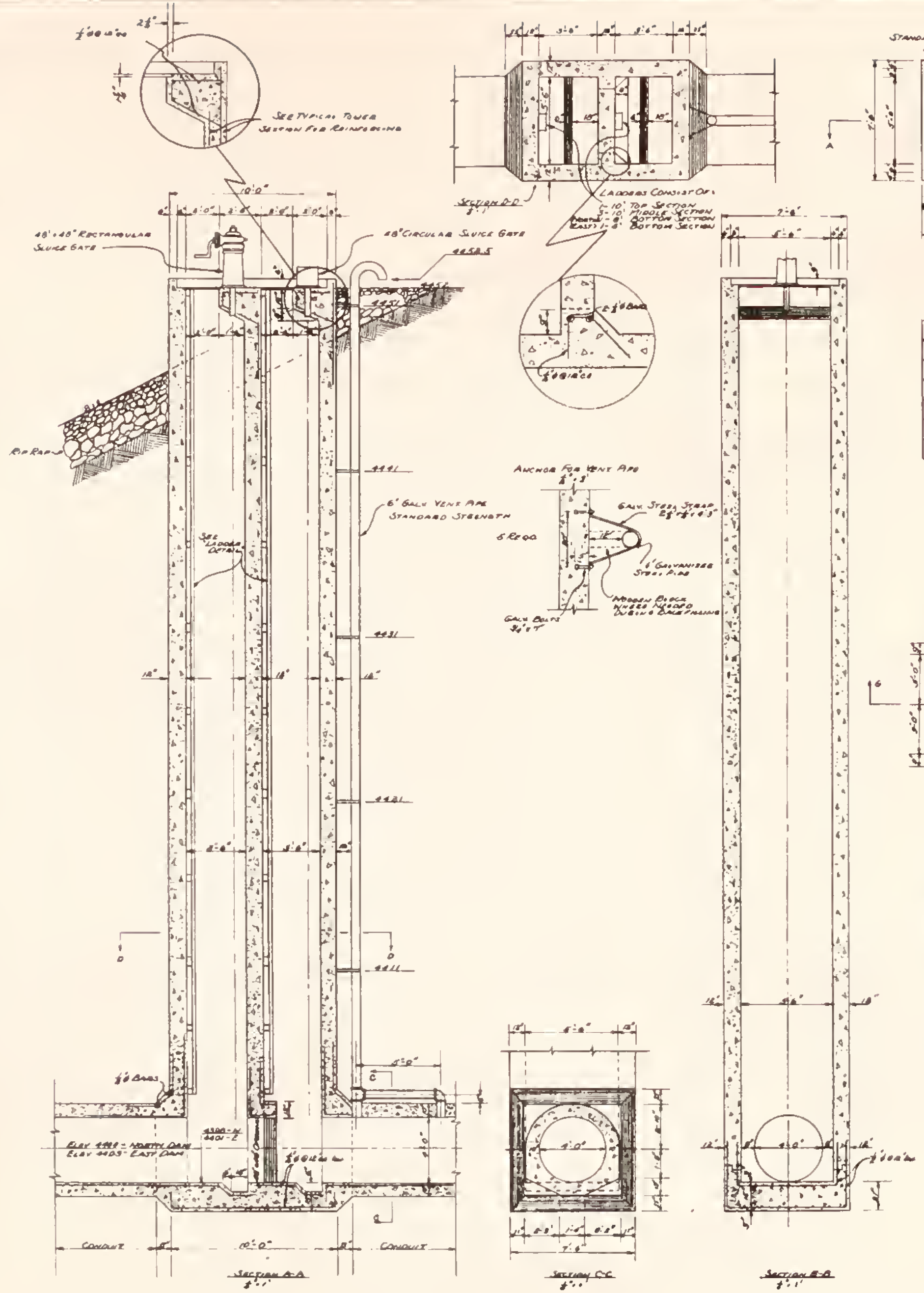
DWG. NO. 73 - 2

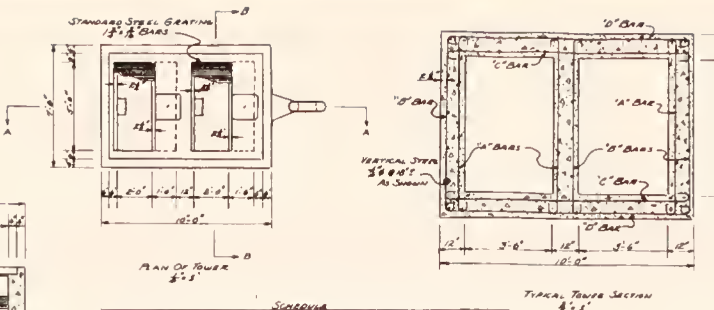
George T.



NOTE :-
See Dwg No. 73-2 for Section of Dam
North & East Dams are similar

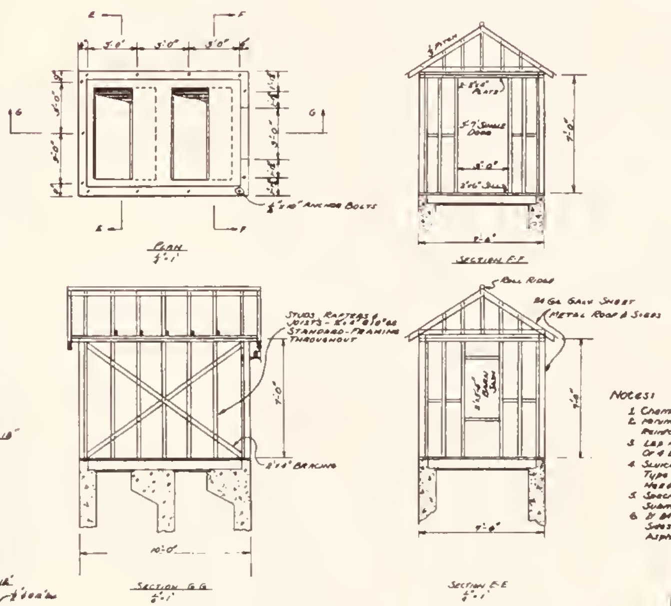
DETAILS-NORTH DAM
NILAN STORAGE PROJECT
LEWIS & CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA AUG. 1950
DWG. NO. 73-1

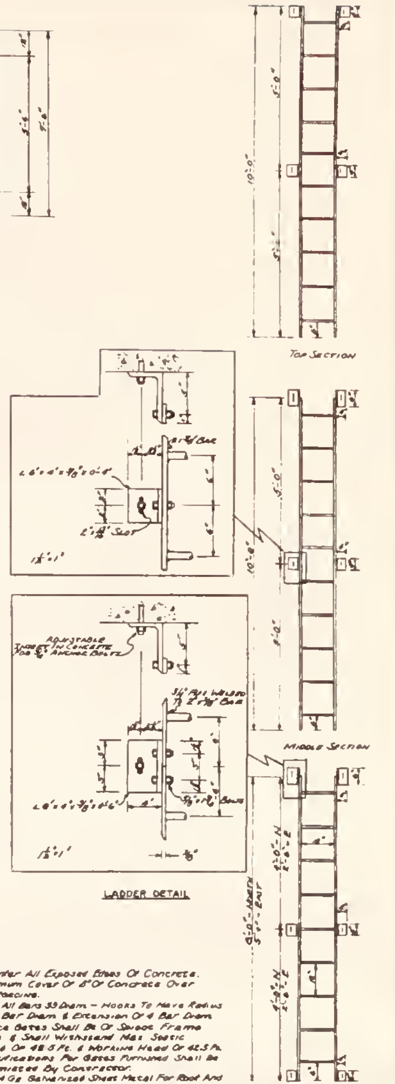




SCHEDULE

DAM	ELEVATION	"A" BARS	"B" BARS	"C" BARS	"D" BARS
NORTH EAST	4390-4403 4401-4403	—	—	½"⌀ @ 7"	½"⌀ @ 10"
BOTH	4403-4409	½"⌀ @ 5"	½"⌀ @ 7½"	½"⌀ @ 8"	½"⌀ @ 12"
BOTH	4409-4416	½"⌀ @ 6"	½"⌀ @ 8½"	½"⌀ @ 9½"	½"⌀ @ 12"
BOTH	4416-4423	½"⌀ @ 7½"	½"⌀ @ 10"	½"⌀ @ 12"	½"⌀ @ 12"
BOTH	4423-4427	½"⌀ @ 10"	½"⌀ @ 12"	½"⌀ @ 12"	½"⌀ @ 10"
BOTH	4427-4458	½"⌀ @ 12"	½"⌀ @ 10"	½"⌀ @ 12"	½"⌀ @ 12"


Plan
Anchor Bolts
Section F-F
Roll Ridge
24 Ga Galv Sheet Metal Roof & Sides
Studs, Rafters, Joists - 2x4 @ 16" oc Standard Framing Throughout
Bracing
Section G-G
Section E-E



Notes:

1. Chamfer All Exposed Edges Of Concrete.
2. Minimum Cover Of 3" Of Concrete Over Reinforcing.
3. Lap All Bars 33 Diam — Hooks To Have Radius Of 4 Bar Diam & Extension Of 4 Bar Diam
4. Sluice Gates Shall Be Of Sheet Frame Type & Shall Withstand Max Static Head Of 48.5 Ft. & Working Head Of 42.5 Ft.
5. Specifications For Gates Furnished Shall Be Submitted By Contractor.
6. If 24 Ga Galvanized Sheet Metal For Roof And Sides Of Control House Is Unavailable, Use Asphalt Roll Roofing & Siding Over 1" Shiplap.

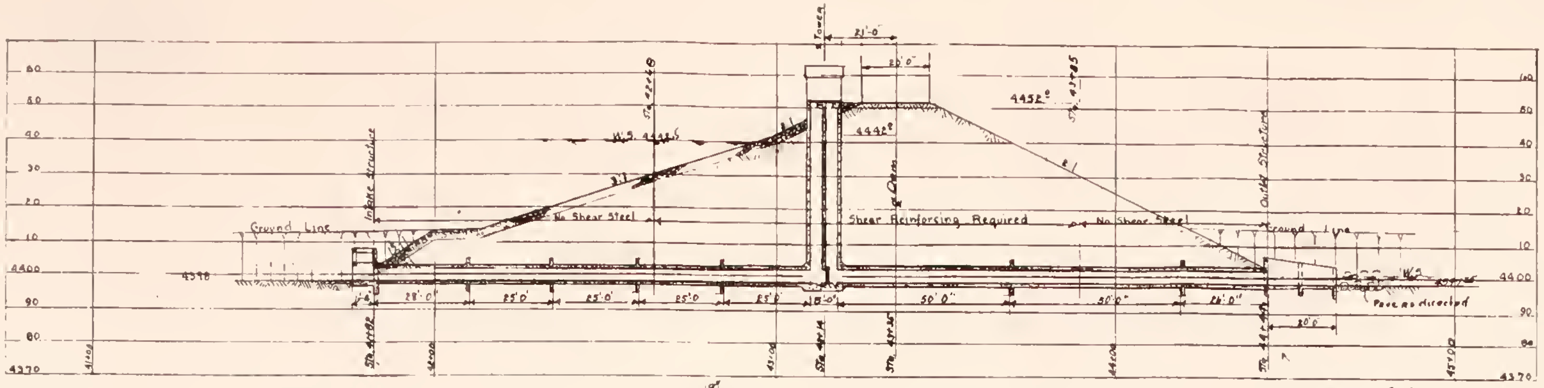
CONTROL WORKS
CONTROL TOWER – DETAILS
NILAN STORAGE PROJECT
LEWIS AND CLARK COUNTY
STATE WATER CONSERVATION BOARD

HELENA, MONTANA
AUGUST, 1950

SCALE AS SHOWN

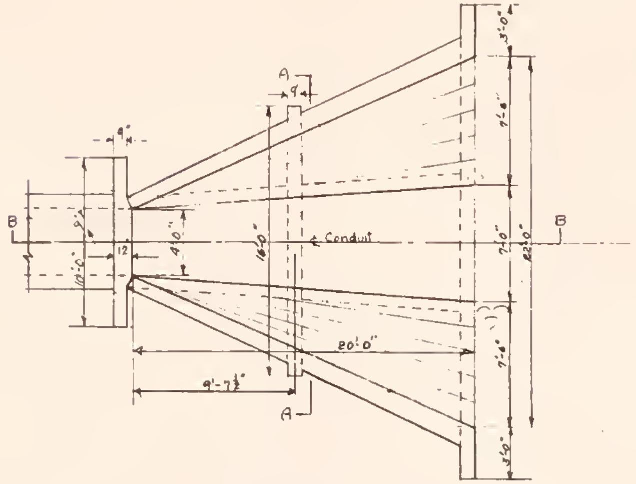
DWG. 33-5

DRAWN BY: RMS

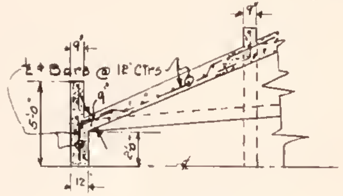


PROFILE ALONG CONDUIT - NORTH DAM

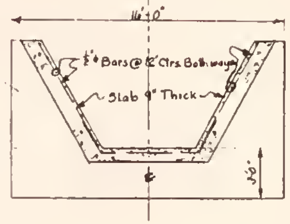
Scale 1" = 20ft.



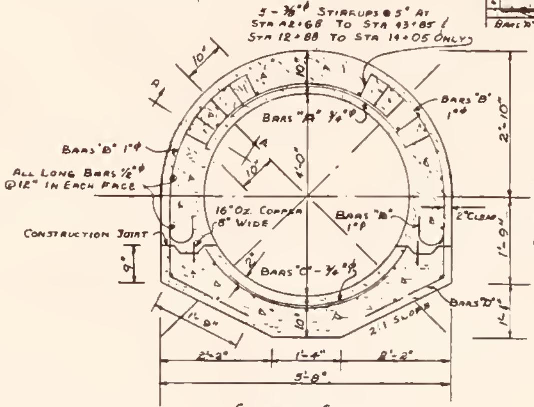
PLAN



SECTION C-C

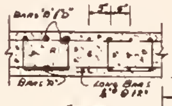


SECTION A-A

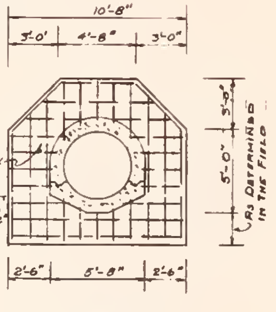


CONDUIT SECTION

¾" = 1'



SECTION A-A


10'-8"
3'-0"
4'-8"
3'-0"
½"φ Bars @ 12" O.C. In Center Of Cutoff. Where Bars Intersect Conduit, Bend Into Conduit 12"
3'-0"
5'-0"
As Determined In The Field
2'-6"
5'-8"
2'-6"

9" CONDUIT CUTOFF

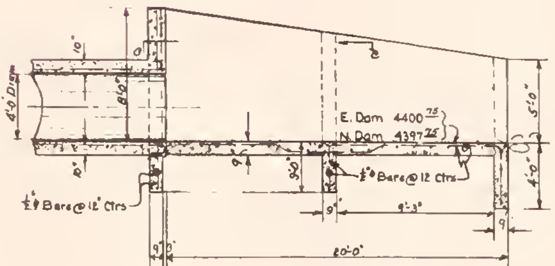
¼" = 1'

SCHEDULE OF CONDUIT REINFORCING

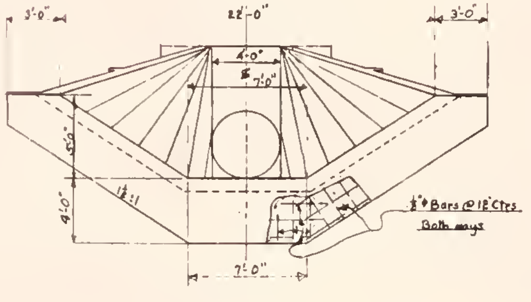
North Dam Stationing	East Dam Stationing	"A"-Bars	"B"-Bars	"C"-Bars	"D"-Bars
42 + 98 - 43 + 65	13+18 - 13+85	¾"φ @ 5"	1"φ @ 10"	¾"φ @ 6"	1"φ @ 10"
42 + 68 - 42 + 98 43 + 65 - 43 + 85	12+88 - 13+18 13+85 - 14+05	¾"φ @ 6"	1"φ @ 12"	¾"φ @ 8"	1"φ @ 12"
42 + 38 - 42 + 68 43 + 85 - 44 + 05	12+58 - 12+88 14+05 - 14+25	¾"φ @ 8"	1"φ @ 20"	¾"φ @ 10"	1"φ @ 20"
42 + 08 - 42 + 38 44 + 05 - 44 + 25	12+28 - 12+58 14+25 - 14+45	¾"φ @ 10"	1"φ @ 24"	¾"φ @ 12"	1"φ @ 24"
41 + 82 - 42 + 08 44 + 25 - 44 + 44	12+09 - 12+28 14+45 - 14+59	¾"φ @ 14"	1"φ @ 24"	¾"φ @ 15"	1"φ @ 24"

General Notes:

Chamfer All Exposed Edges Of Concrete 1". Min Cover Of 2" Of Concrete Over Reinforcing. Lap All Bars 33 Diam. Hooks To Have Radius Of 4 Bar Diam. And Extension Of 4 Bar Diam.



SECTION B-B



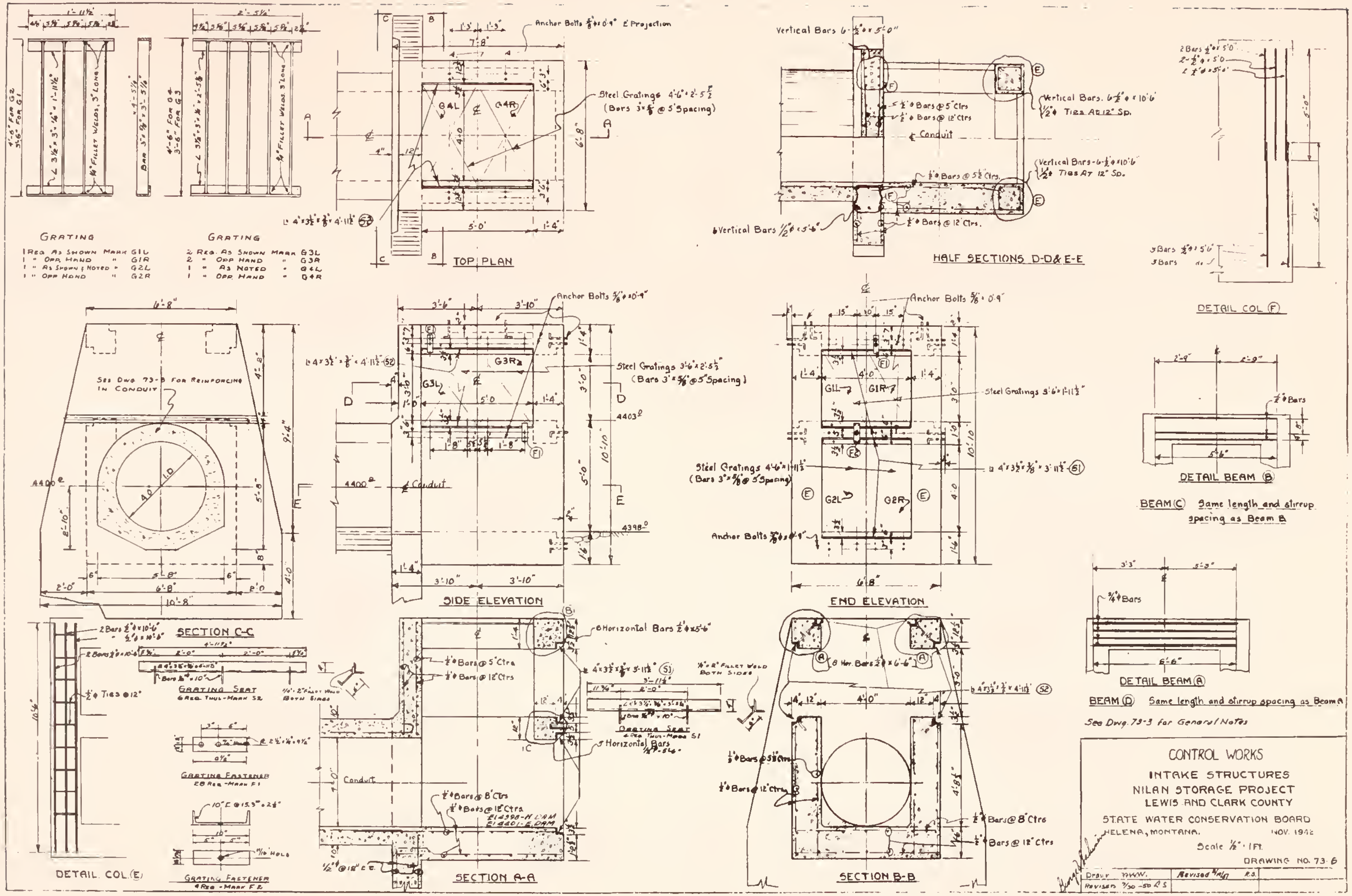
END ELEVATION

OUTLET STRUCTURE

Scale ¼" = 1 Ft.

1. "A" Bars Alternate Bars Reverse In Position As Shown Except From Sta 42+68 To Sta 43+85, North Dam, And Sta 12+88 To Sta. 14+05, East Dam, Where Stirrups Are Reqd. And All Bars End 10" Below 45° Line
2. "B" Bars Begin With Hooks At Construction Joint & End 10" Above 45° Line.
3. "C" Bars Alternate Bars Reverse In Position As Shown.
4. "D" Bars Begin Near Invert End And End At 45° Line Except From Sta 42+68 To Sta. 43+85, And Sta. 12+88 To Sta 14+05 Where Stirrups Are Reqd And All Bars End 10" Above 45° Line
5. All Longitudinal Bars ½"φ @ 12" In Each Face.
6. Stirrups ⅜"φ @ 5" From Sta 42+68 To 43+85, North Dam, And Sta 12+88 To Sta. 14+05, East Dam.
7. 16 Oz. Copper Seal - 8" Wide Shall Be Placed In All Construction Joints.

CONTROL WORKS - NORTH DAM
CONDUIT & OUTLET STRUCTURES
NILAN STORAGE PROJECT
LEWIS AND CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA DEC. 1942
Scale - as shown
DRAWING NO 73-3
Drawn P.K.W.
Rev 7/28 - 1950, L.S.


GRATING
1 Req. As Shown Mark G1L
1 " Opp. Hand " G1R
1 " As Shown & Noted " G2L
1 " Opp. Hand " G2R
GRATING
2 Req. As Shown Mark G3L
2 " Opp. Hand " G3R
1 " As Noted " G4L
1 " Opp. Hand " G4R
TOP PLAN
Anchor Bolts 5/8"φ×0'-9" ℄ Projection
Steel Gratings 4'-6"×2'-5 1/2" (Bars 3"×5/8" @ 5" Spacing)
HALF SECTIONS D-D & E-E
Vertical Bars 6-1/2"φ×5'-0"
Vertical Bars 6-1/2"φ×10'-6"
1/2"φ Ties At 12" Sp.
Conduit
DETAIL COL. Ⓕ
SECTION C-C
See Dwg. 73-B For Reinforcing In Conduit
SIDE ELEVATION
Steel Gratings 3'-6"×2'-5 1/2" (Bars 3"×5/8" @ 5" Spacing)
END ELEVATION
Steel Gratings 3'-6"×1'-11 1/2"
Steel Gratings 4'-6"×1'-11 1/2" (Bars 3"×5/8" @ 5" Spacing)
Anchor Bolts 5/8"φ×0'-9"
DETAIL BEAM Ⓑ
BEAM Ⓒ Same length and stirrup spacing as Beam B
DETAIL BEAM Ⓐ
BEAM Ⓓ Same length and stirrup spacing as Beam A
See Dwg. 73-3 for General Notes
DETAIL COL. Ⓔ
GRATING SEAT 6 Req. Thus - Mark S2
GRATING FASTENER 28 Req. - Mark F1
GRATING FASTENER 4 Req. - Mark F2
GRATING SEAT 4 Req. Thus - Mark S1
SECTION A-A
SECTION B-B
Conduit

CONTROL WORKS

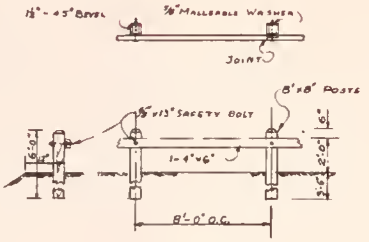
INTAKE STRUCTURES
NILAN STORAGE PROJECT
LEWIS AND CLARK COUNTY

STATE WATER CONSERVATION BOARD
HELENA, MONTANA. NOV. 1942

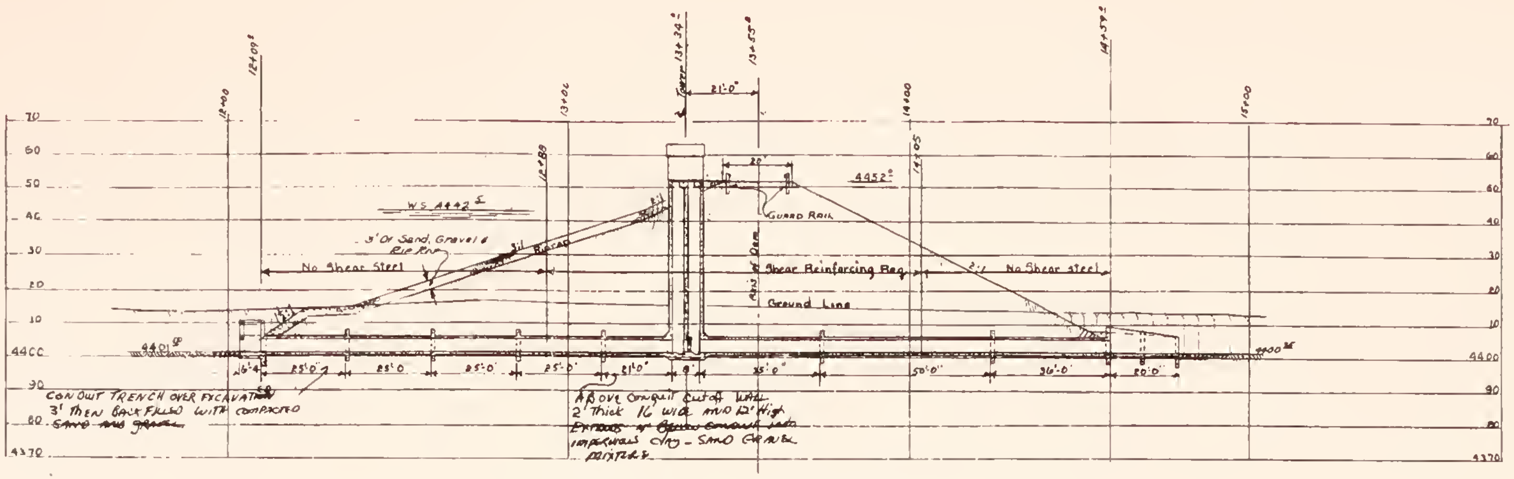
Scale 1/2" = 1 Ft.

DRAWING NO. 73-6

Drawn W.W.W.	Revised 4/1/47 R.S.	
Revised 7/30-50 R.S.		

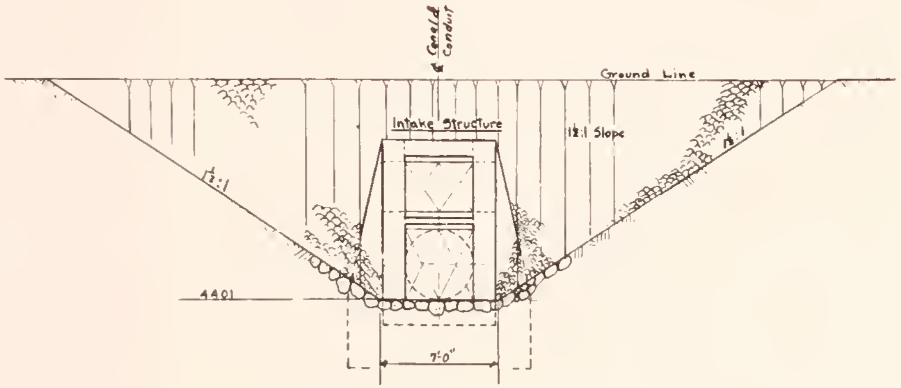


Details Of Wood Guard Rail
Scale ~ ½"=1'



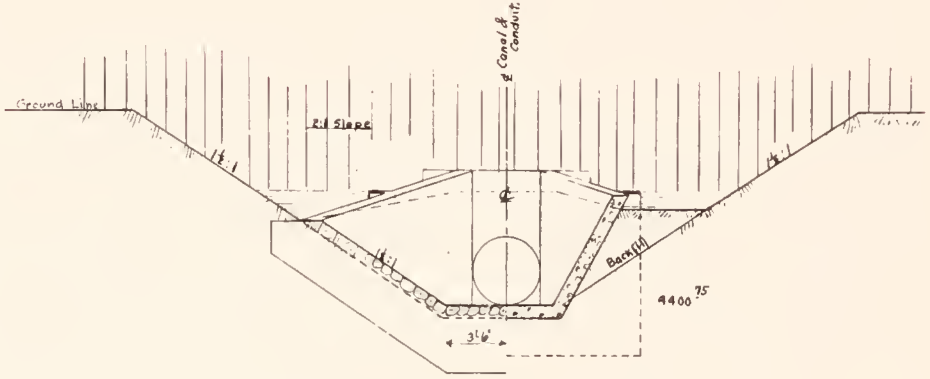
PROFILE ALONG CONDUIT - EAST DAM

Scale 1" = 20ft.



SECTION SHOWING GRADING AT INTAKE

Scale ¼" = 1ft.



HALF SECTION AT END OF OUTLET STRUCTURE

HALF SECTION MIDWAY OF STRUCTURE

SHOWING GRADING AT OUTLET

Scale ¼" = 1ft.

References:

North Dam
- Intake Structure — Dwg No 6
- Control Tower — " " 5
- Conduit & Outlet Structure — " " 3

Conduit and Control Tower Details similar to North Dam.

Intake and Outlet Structures same as for North Dam except for Elevation.

CONTROL WORKS
EAST DAM
NILAN STORAGE PROJECT
LEWIS AND CLARK COUNTY
STATE WATER CONSERVATION BOARD
HELENA, MONTANA. DEC. 1942
Scale - as shown
DRAWING NO. 73-4
Drawn P.H.W.